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CHAPTERS ON THE STARS.

By PROFESSOR SIMON NEWCOMB, U. S. N.

BINARY AND MULTIPLE SYSTEMS.

SIR WILLIAM HERSCHEL was the first to notice that many stars which, to the unaided vision, seemed single, were really composed of two stars in close proximity to each other. The first question to arise in such a case would be whether the proximity is real or whether it is only apparent, arising from the two stars being in the same line from our system. This question was speedily settled by more than one consideration. If there were no real connection between any two stars, the chances would be very much against their lying so nearly in the same line from us as they are seen to do in the case of double stars. Out of 5,000 stars scattered at random over the celestial vault the chances would be against more than three or four being so close together that the naked eye could not separate them, and would be hundreds to one against any two being as close as the components of the closer double stars revealed by the telescope. The conclusion that the proximity is in nearly all cases real is also proved by the two stars generally moving together or revolving round each other.

Altogether there is no doubt that in the case of the brighter stars all that seem double in the telescope are really companions. But when we come to the thousands or millions of telescopic stars, there may be some cases in which the two stars of a pair have no real connection and are really at very different distances from us. The stars of such a pair are called 'optically double.' They have no especial interest for us and need not be further considered in the present work.

After Herschel, the first astronomer to search for double stars on a large scale was Wilhelm Struve, the celebrated astronomer of

Dorpat. So thorough was his work in this field that he may fairly be regarded as the founder of a new branch of astronomy. Armed with what was, at that time (1815-35), a remarkable refracting telescope, he made a careful search of that part of the sky visible at Dorpat, with a view of discovering all the double stars within reach of his instrument. The angular distance apart of the components and the direction of the fainter from the brighter star were repeatedly measured with all attainable precision. The fine folio volume, 'Mensuræ Micrometricæ,' in which his results were published and discussed, must long hold its place as a standard work of reference on the subject.

Struve had a host of worthy successors, of whom we can name only a few. Sir John Herschel was rather a contemporary than a successor. His most notable enterprise was an expedition to the Cape of Good Hope for the purpose of exploring the southern heavens with greater telescopes that had then been taken to the southern hemisphere. Herschel,

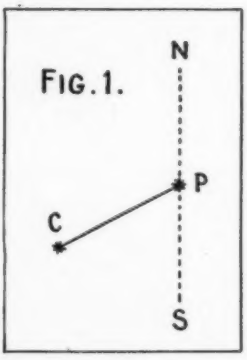

FIG. 1. POSITION-ANGLE AND DISTANCE OF A DOUBLE STAR.

South and Dawes, of England, were among the greatest English observers about the middle of the century. Otto Struve, son of Wilhelm, continued his father's work with zeal and success at Pulkowa. Later one of the most industrious observers was Dembowski, of Italy. During the last thirty years one of the most successful cultivators of double-star astronomy has been Burnham, of Chicago. He is to-day the leading authority on the subject. Enthusiasm, untiring industry and wonderful keenness of vision have combined to secure him this position.

The particulars which the careful observer of a double star should record are the position-angle and distance of the components and their respective magnitudes. To these Struve added their colors; but this has not generally been done.

Let P be the principal star and C the companion. Let N S be a north and south line through P, or an arc of the celestial meridian, the direction N being north and S south from the star P.

Then, the angle N P C is called the *position-angle* of the pair. It is counted round the circle from 0° to 360°. The angle drawn in the figure is nearly 120°. Were the companion C in the direction S the position angle would be 180°; to the right of P it would be 270°; to the right of N it would be between 270° and 360°.

The *distance* is the angle P C, which is expressed in seconds of arc.

We cannot set any well-defined limits to the range of distance. The general rule is that the greater the distance beyond a few seconds the less the interest that attaches to a double star, partly because the observation of distant pairs offers no difficulty, partly because of the increasing possibility that the components have no physical connection and so form only an optically double star. With every increase of telescopic power so many closer and closer pairs are found that we cannot set any limit to the number of stars that may have companions. It is therefore to the closer pairs that the attention of astronomers is more especially directed.

The difficulty of seeing a star as double, or, in the familiar language of observers, of 'separating' the components, arises from two sources, the proximity of the companion to the principal star and the difference in magnitude between the two. It was only in rare cases that Struve could separate a pair of distance half a second. Now Burnham finds pairs whose distance is one-quarter of a second or less; possibly the limit of a tenth of a second is being approached. It goes without saying that a very minute companion to a bright star may, when the distance is small, be lost in the rays of its brighter neighbor. For all these reasons no estimate can be made of the actual number of double stars in the heavens. With every increase of telescopic power and observing skill more difficult pairs are being found without a sign of a limit.

The great interest which attaches to double stars arises from the proof which they afford that the law of gravitation extends to the stars. Struve, by comparing his own observations with each other, or with those of Herschel, found that many of the pairs which he measured were in relative motion; the position angle progressively changing from year to year, and sometimes the distance also. The lesser star was therefore revolving round the greater, or, to speak with more precision, both were revolving round their common center of gravity. To such a pair the name *binary system* is now applied.

There can be no reasonable doubt that the two components of all physically connected double stars revolve round each other. If they did not their mutual gravitation would bring them together and fuse them into a single mass. We are therefore justified in considering all double stars as binary systems, except those which are merely optically double. For reasons already set forth, the pairs of the latter

class which are near together must be very few in number; indeed, there are probably none among the close double stars whose brightest component can be seen by the naked eye.

The time of revolution of the binary systems is so long that there are only about fifty cases in which it has yet been determined with any certainty. Leaving out the 'spectroscopic binaries,' to be hereafter described, the shortest period yet found is eleven years. In only a small minority of cases is the period less than a century. In the large majority either no motion at all has yet been detected, or it is so slow as to indicate that the period must be several centuries, perhaps several thousand years.

There is a great difficulty in determining the period with precision until the stars have been observed through nearly a revolution, owing to the number of elements, seven in all, that fix the orbit, and the difficulty of making the measures of position angle and distance with precision. It thus happens that many of the orbits of binary systems which have been computed and published have no sound basis. Two cases in point may be mentioned.

The first magnitude star Castor, or α Geminorum, can be seen to be double with quite a small telescope. The components are in relative motion. Owing to the interesting character of the pair it has been well observed, and a number of orbits have been computed. The periodic times found by the components have a wide range. The fact is, nothing is known of the period except that it is to be measured by centuries, perhaps by thousands of years.

The history of 61 Cygni, a star ever memorable from being the first of which the parallax was determined, is quite similar. Although, since accurate observations have been made on it the components have moved through an apparent angle of 30°, the observations barely suffice to show a very slight curvature in the path which the two bodies are describing round each other. Whether the period is to be measured by centuries or by thousands of years cannot be determined for many years to come.

In his work on the 'Evolution of the Stellar Systems,' Prof. T. J. J. See has investigated the orbits of forty double stars having the shortest periods. There are twenty-eight periods of less than one hundred years

In considering the orbits of binary systems we must distinguish between the actual and the apparent orbit. The former is the orbit as it would appear to an observer looking at it from a direction perpendicular to its plane. This orbit, like that of a planet or comet moving round the sun, is an ellipse, having the principal star in its focus. The point nearest the latter is called the periastron, or pericenter, and corresponds to the perihelion of a planetary orbit. The point most distant from the principal star is the apocenter. It is opposite the

pericenter and corresponds to the aphelion of a planetary orbit. The law of motion is here the same as in the case of a body of the solar system; the radius vector, joining the two bodies, sweeps over equal areas in equal times. The apparent orbit is the orbit as it appears to us. It differs from the actual orbit because we see it from a more or less oblique direction. In some cases the plane of the orbit passes near our system. Then to us the orbit will appear as a straight line and the small star will seem to swing from one side of the large one to the other like a pendulum, though the actual orbit may differ little from a circle. In some cases there may be two pericenters and two apocenters to the apparent orbit. This will be the case when a nearly circular orbit is seen at a considerable obliquity.

It is a remarkable and interesting fact that the law of areas holds good in the apparent as in the actual orbit. This is because all parts of the plane of the orbit are seen at the same angle, so that the obliquity of vision diminishes all the equal areas in the same proportion and thus leaves them equal.

The two most interesting binary systems are those of Sirius and Procyon. In the case of each the existence and orbit of the companion were inferred from the motions of the principal star before the companion had been seen. Before the middle of the century it was found that Sirius did not move with the uniform proper motion which characterizes the stars in general; and the inequality of its motion was attributed to the attraction of an unseen satellite. Later Auwers, from an exhaustive investigation of all the observations of the star, placed the inequality beyond doubt and determined the elements of the orbit of the otherwise unknown satellite. Before his final work was published the satellite was discovered by Alvan G. Clark, of Cambridgeport, Mass., son and successor of the first and greatest American maker of telescopes. Additional interest was imparted to the discovery by the fact that it was made in testing a newly constructed telescope, the largest refractor that had been made up to that time. The discoverer was, at the time, unaware of the work of Peters and Auwers demonstrating the existence of the satellite. The latter was, however, in the direction predicted by Auwers, and a few years of observation showed that it was moving in fairly close accordance with the prediction.

The orbit as seen from the earth is very eccentric, the greatest distance of the satellite from the star being about ten seconds, the least less than three seconds. Owing to the brilliant light of Sirius the satellite is quite invisible, even in the most powerful telescopes, when nearest its primary. This was the case in the years 1890-92 and will again be the case about 1940, when another revolution will be completed.

The history of Procyon is remarkably similar. An inequality of its motion was suspected, but not proved, by Peters. Auwers showed from

observations that it described an orbit seemingly circular, having a radius of about 1″. There could be no doubt that this motion must be due to the revolution of a satellite, but the latter long evaded discovery, though carefully searched for with the new telescopes which were from time to time brought into use. At length in 1895 Schaeberle found the long-looked-for object with the 36-inch telescope of the Lick Observatory. It was nearly in the direction predicted by Auwers, and a year's observation by Schaeberle, Barnard and others showed that it was revolving in accordance with the theory.

If the conclusion of Auwers that the apparent orbit of the principal star is circular were correct, the distance of the satellite should always be the same. It would then be equally easy to see at all times. The fact that neither Burnham nor Barnard ever succeeded in seeing the

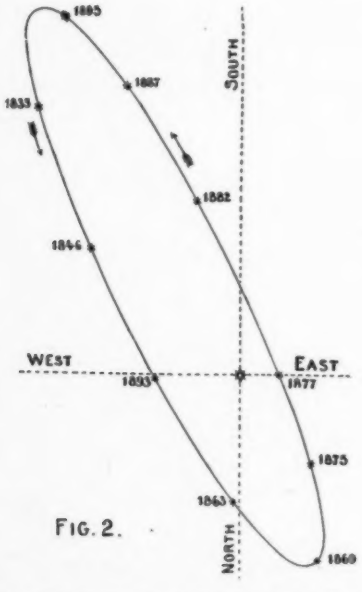

FIG. 2. APPARENT ORBIT OF ∝ CENTAURI, BY PROFESSOR SEE.

object with the Lick telescope would then be difficult to account for. The fact is, however, that the periodic motion of Procyon is so small that a considerable eccentricity might exist without being detected by observations. The probability is, therefore, that the apparent orbit is markedly eccentric and that the satellite was nearer the primary during the years 1878-92 than it was when discovered.

One very curious feature, common to both of these systems, is that the mass of each satellite, as compared with that of its primary, is out of all proportion to its brightness. The remarkable conclusions to be drawn from this fact will be discussed in a subsequent chapter.

The system of α Centauri is interesting from the shortness of the period, the brightness of the stars and the fact that it is the nearest star to us so far as known. We reproduce a diagram of the apparent orbit from Dr. See's work. The period of revolution found by Dr. See is eighty-one years. The major axis of the apparent orbit is 32″; of the minor axis 6″.

The pairs of which, so far as known, the period of revolution is the shortest, are these:

				Years.
ζ Pegasi;	R. A. = 21h. 40m.;	Dec. = + 25°11′;	Period =	11. 42.
δ Equulei;	" = 21h. 10m.;	" + 9°37′;	" =	11. 45.
ξ Sagittarii;	" = 18h. 56m.;	" − 30° 1′;	" =	18. 85.
ρ Argus;	" = 7h. 47m.;	" − 13°38′;	" =	22. 00.
85 Pegasi;	" = 23h. 57m.;	" + 26°34′;	" =	24. 00.

TRIPLE AND MULTIPLE SYSTEMS.

Systems of three or more stars so close together that there must be a physical connection between them are quite numerous. There is every variety of such systems. Sometimes a small companion of a brighter star is found to be itself double. A curious case of this sort is that of γ Andromedæ. This object was observed and measured by Struve as an ordinary double star, of which the companion was much smaller than the principal star. Some years later Alvan Clark found that this companion was itself a close double star, of which the components, separated by about 1″, were nearly equal. Moreover, it was soon found that these components revolved round each other in a period not yet accurately determined, but probably less than a century. Thus we have a binary system revolving round a central star, as the earth and moon revolve round the sun.

In most triple systems there is no such regularity as this. The magnitudes and relative positions of the components are so varied that no general description is possible. Stars of every degree of brightness are combined in every way. Observations on these systems extend over so short an interval that we have no data for determining the laws of motion that may prevail in any but one or two of the simplest cases. They are, in all probability, too complicated to admit of profitable mathematical investigation. There is, therefore, little more of interest to be said about them.

There is a very notable multiple system known as the Trapezium of Orion, from the fact that it is composed of four stars, one of which is plainly visible to the naked eye, while the others may be well seen in the smallest telescope. There are also two other very faint stars, each of which seems to be a companion of one of the bright ones. This system is situated in the great nebulæ of Orion, to be described in the next

chapter, a circumstance which has made it one of the most interesting objects to observers. No motion has yet been certainly detected among the components.

SPECTROSCOPIC BINARY SYSTEMS.

Among the many striking results of recent astronomical research it would be difficult to name any more epoch-making than the discovery that great numbers of the stars have invisible dark bodies revolving round them of a mass comparable with their own. The existence of these revolving bodies is made known not only by their eclipsing the star, but by producing a periodic change in the radial motion of the star. How their motion is determined by means of the spectroscope has been briefly set forth in a former chapter. As a general rule the motion is uniform in the case of each star. We have described in a former chapter the periodic character of the radial motion of Algol, discovered by Vogel. This was followed by the discovery that α Virginis, though not variable, was affected by a similar inequality of the radial motion, having a period of four days and nineteen minutes. The velocity of the star in its apparent orbit is very great, about ninety-one kilometers, or fifty-six English miles, per second. It follows that the radius of the orbit is some three million miles. The mass of the invisible companion must, therefore, be very great.

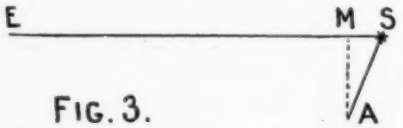

FIG. 3.

FIG. 3. RADIAL MOTION OF A BINARY SYSTEM.

A new form of binary system was thus brought out which, from the method of discovery, was called the spectroscopic binary system. But there is really no line to be drawn between these and other binary systems. We have seen that as telescopic power is increased, closer and closer binary systems are constantly being formed. We naturally infer that there is no limit to the proximity of the pairs of stars of such systems and that innumerable stars may have satellites, planets or companion stars so close or so faint as to elude our powers of observation. Still, there is as yet a wide gap between the most rapidly moving visible binary system and the slowest spectroscopic one, which, however, will be filled by continued observation.

The actual orbit of such a system cannot be determined with the spectroscope, because only one component of the motion, that in the direction of the earth, can be observed. In the case of an orbit of which the plane was perpendicular to the line of sight from the earth

to the star the spectroscope could give us no information as to the motion. The motion to or from the earth would be invariable. To show the result of the orbit being seen obliquely, let E be the earth and A S be the plane of the orbit seen edgewise. Drop the perpendicular A M upon the line of sight. Then, while the star is moving from S to A the spectroscope will measure the motion as if it took place from S to M. Since S M is less than A S, the measured velocity will always be less than the actual velocity, except in the rare case when the plane of the orbit is directed toward the earth. Since the spectroscope can give us no information as to the inclination under which we see the orbit, it follows that the actual orbital velocities of the spectroscopic binaries must remain unknown. We can only say that they cannot be less, but may be greater to any extent than that shown by our measures.

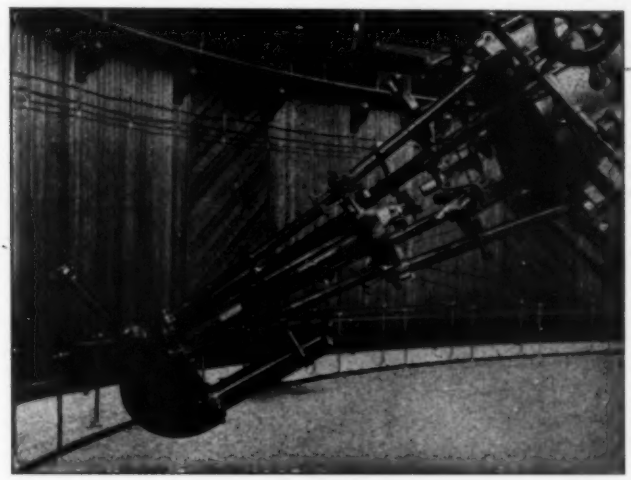

FIG. 4. THE MILLS SPECTROGRAPH OF THE LICK OBSERVATORY.

If the components of a binary system do not differ greatly in brightness, its character may be detected without actually measuring the radial velocities. Since the motion is shown by a displacement of the spectral lines and since, in any binary system, the two components must always move in opposite directions, it follows that the displacements of the spectral lines of the two stars will be in opposite directions. Hence, when one of the stars, say A, is moving toward us, and the other, say D, from us, all the spectral lines will appear double, the lines made by A being displaced toward the blue end of the spectrum and those by B toward the red end. After half a revolution the motion will be reversed and the lines will again be double; only the lines of star A will now be on the red side of the others. Between these two phases will

be one in which the radial velocities of the two stars are the same; the lines will then appear single.

The first star of which the binary character was detected in this way is ξ Ursæ Majoris. The discovery was made at the Harvard Observatory. Capella is supposed to be another of the same class.

About 1896 the Lick Observatory was supplied with the best spec-

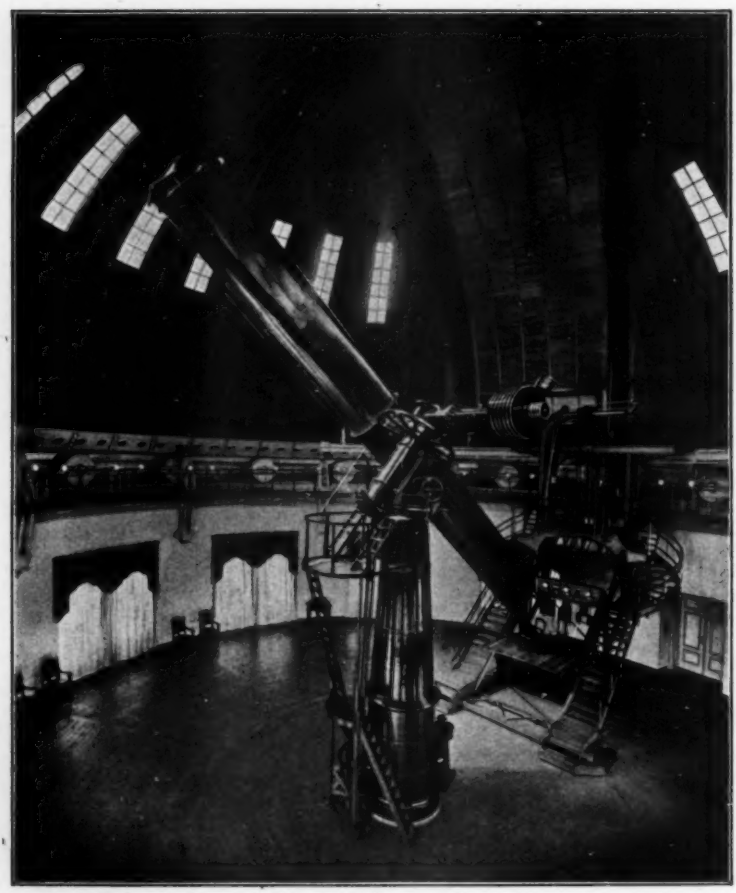

FIG. 5. THE NEW PHOTOGRAPHIC REFRACTING TELESCOPE OF THE ASTROPHYSICAL OBSERVATORY AT POTSDAM, NEAR BERLIN.

trograph that Brashear could produce, the gift of Mr. D. O. Mills. In the hands of Campbell the measurements of radial motion with this instrument have reached an extraordinary degree of precision and brought to light the fact that systems of the kind in question are more numerous than would ever have been suspected. Campbell believes that the radial motion of about one star in every thirteen is affected by

an observable inequality. Such an inequality can arise only through the action of a neighborhood of a mass at least comparable with that of our sun. A new field of astronomical research is thus opened, the exploration of which must occupy many years. The ultimate result may be to make as great an addition to our knowledge of the heavens as has been made during the last century by the telescope.

STAR-CLUSTERS.

A star-cluster is a bunch or collection of stars separated from the great mass of stars which stud the heavens. The Pleiades, or 'seven stars,' as they are familiarly called, form a cluster, of which six of the components are easily seen by the naked eye, while five others may be distinguished by a good eye.

About 1780 Michell, of England, raised the question whether, supposing the stars visible to the naked eye to be scattered over the sky at random, there would be a reasonable possibility that those of the Pleiades would all fall within so small a space as that filled by the constellation. His correct conclusion was in the negative. It follows that this cluster does not consist of disconnected stars at various distances, which happen to be nearly in a line from our system, but is really a collection of stars by itself. Besides the stars visible to the naked eye, the Pleiades comprise a great number of telescopic stars, of which about sixty have been catalogued and their relative positions determined. The principal star of the cluster is Alcyone or η Tauri, which is of the third magnitude. The five which come next in the order of brightness are not very unequal, being all between the fourth and fifth magnitudes. Six are near the sixth magnitude. The remainder, so far as catalogued, range from the seventh to the ninth.

In this case there is a fairly good method of distinguishing between a star which belongs to the cluster and one which probably lies beyond it. This test is afforded by the proper motion. All the stars of the group have a common proper motion in the same direction of about seven seconds per century. The first accurate measures made on the relative positions of the stars of the cluster were those of Bessel, about 1830. In recent years several observers have made yet more accurate determinations. The most thorough recent discussion is by Elkin. One result of his work is that there is as yet no certain evidence of any relative motion among the stars of the group. They all move on together with their common motion of seven seconds per century, as if they were a single mass.

A closer cluster, which is plainly visible to the naked eye and looks like a cloudy patch of light, is Præsepe in Cancer. It is very well seen in the early evenings of winter and spring. Although there is nothing in the naked-eye view to suggest a star, it is found on telescopic ex-

amination that the individual stars do not fall far below the limit of visibility, several being of about the seventh magnitude.

Another notable cluster of the same general nature is that in Perseus. This constellation is situated in the Milky Way, not far from its region of nearest approach to the pole. In the figure of the constellation the cluster forms the handle of the hero's sword. It may be seen

FIG. 6. THE GREAT CLUSTER IN HERCULES, AS PHOTOGRAPHED WITH THE CROSSLEY REFLECTOR OF THE LICK OBSERVATORY.

in the evening during almost any season except summer. To the naked eye it seems more diffused and star-like than Præsepe; in fact, it has two distinct centers of condensation, so that it may be considered as a double cluster.

The two clusters last described may be resolved into stars with the smallest telescopes. But in the case of most of these objects the in-

dividual stars are so faint that the most powerful instruments scarcely suffice to bring them out. One of the most remarkable clusters in the northern heavens is that of Hercules. To the naked eye it is but a faint and insignificant patch which would be noticed only by a careful observer. But in a large telescope it is seen to be one of the most interesting objects in the heavens. Near the border the individual stars can be readily distinguished. But they grow continually thicker toward the center, where, even in a telescope of two feet aperture, the

FIG. 7. THE CLUSTER ω CENTAURI, PHOTOGRAPHED BY GILL AT THE CAPE OBSERVATORY.

observer can see only a patch of light, which is, however, as he scans it, suggestive of the countless stars that must there be collected. By the aid of photography, Professor Pickering has nearly succeeded in the complete resolution of this cluster.

In many cases the central portions of these objects are so condensed that they cannot be visually resolved into their separate stars, even with the most powerful telescopes. A closer approach to complete resolution has been made by photography. We present copies of several photographs which have been made by Pickering, Gill and others.

The cluster which, according to Pickering, may be called the finest in the sky, is ω Centauri. It lies just within the border of the Milky Way, in right ascension, 13h. 20.8m., and declination —46° 47′. There are no bright stars near. To the naked eye it appears as a hazy star of the fourth magnitude. Its actual extreme diameter is about 40′. The brightest individual stars within this region are between the eighth and ninth magnitudes. Over six thousand have been counted on one of the photographs and the whole number is much greater.

The most remarkable and suggestive feature of the principal clusters is the number of variable stars which they contain. This feature has been brought out by the photographs taken at the Harvard Observatory and at its branch station in Arequipa. The count of stars and the detection of the variables was very largely made by Professor Bailey, who, for several years past, has been in charge of the Arequipa station. The proportion of variables is very different in different clusters. In the double cluster, 869-884, only one has been found among a thousand stars. The richest in variables is Messier, 3, in which one variable has been detected among every seven stars. It might be suspected that the closer and more condensed the cluster the greater the proportion of variables. This, however, does not hold universally true. In the great cluster of Hercules only two variables are found among a thousand stars.

Very remarkable, at least in the case of ω Centauri, is the shortness of the period of the variables. Out of one hundred and twenty-five found, ninety-eight have periods less than twenty-four hours. On the subject of the law of variation in these cases, Pickering says:

"The light curves of the ninety-eight stars whose periods are less than twenty-four hours may be divided into four classes. The first is well represented by No. 74. The period of this star is 12h. 4m. 3s. and the range in brightness two magnitudes. Probably the change in brightness is continuous. The increase of light is very rapid, occupying not more than one-fifth of the whole period. In some cases, possibly in this star, the light remains constant for a short time at minimum. In most cases, however, the change in brightness seems to be continuous. The simple type shown by No. 74 is more prevalent in this cluster than any other. There are, nevertheless, several stars, as No. 7, where there is a more or less well marked secondary maximum. The period of this star is 2d. 11h. 51m. and the range in brightness one and a half magnitudes. The light curve is similar to that of well-known short-period variables, as δ Cephei and η Aquilæ. Another class may be represented by No. 126, in which the range is less than a magnitude and the times of increase and decrease are about equal. The period is 8h. 12m. 3s. No. 24 may perhaps be referred to as a fourth type. The range is about seven-tenths of a magnitude and the

period is 11h. 5m. 7s. Apparently about 65 per cent. of the whole period is occupied by the increase of the light. This very slow rate of increase is especially striking from the fact that in many cases in this cluster the increase is extremely rapid, probably not more than ten per cent. of the whole period. In one case, No. 45, having a period of 14h. 8m., the rise from minimum to maximum, a change of two magnitudes takes place in about one hour, and in certain cases, chiefly owing to the necessary duration of a photographic exposure, there is no proof at present that the rise is not much more rapid.

"The marked regularity in the period of these stars is worthy of attention. Several have been studied during more than a thousand, and one during more than five thousand, periods without irregularities manifesting themselves."

It may be added that this regularity of the period, taken in connection with the case of η Aquilæ, already mentioned, affords a strong presumption that the variations in the light of these stars are in some way connected with the revolution of bodies around them, or of one star round another. Yet it is certain that the types are not of the Algol class and that the changes are not due merely to one star eclipsing another. That such condensed clusters should have a great number of close binary systems is natural, almost unavoidable, we might suppose. It will hereafter be shown to be probable that among the stars in general single stars are the exception rather than the rule. If such be the case, the rule should hold yet more strongly among the stars of a condensed cluster.

Perhaps the most important problem connected with clusters is the mutual gravitation of their component stars. Where thousands of stars are condensed into a space so small, what prevents them from all falling together into one confused mass? Are they really doing so, and will they ultimately form a single body? These are questions which can be satisfactorily answered only by centuries of observation; they must, therefore, be left to the astronomers of the future.

NEBULÆ.

The first nebula, properly so-called, to be detected by an astronomical observer was that of Orion. Huyghens, in his 'Systema Saturnium,' gives a rude drawing of this object, with the following description:

"There is one phenomenon among the fixed stars worthy of mention which, so far as I know, has hitherto been noticed by no one, and, indeed, cannot be well observed except with large telescopes. In the sword of Orion are three stars quite close together. In 1656, as I chanced to be viewing the middle one of these with the telescope, instead of a single star, twelve showed themselves (a not uncommon circumstance). Three of these almost touched each other, and, with

four others, shone through a nebula, so that the space around them seemed far brighter than the rest of the heavens, which was entirely clear, and appeared quite black, the effect being that of an opening in the sky, through which a brighter region was visible."

For a century after Huyghens made this observation it does not appear that these objects received special attention from astronomers. The first to observe them systematically on a large scale was Sir Wm. Herschel, whose vast researches naturally embraced them in their scope. His telescopes, large though they were, were not of good defining power and, in consequence, Herschel found it impossible to draw a certain line in all cases between nebulæ and clusters. At his time it was indeed a question whether all these bodies might not be clusters. This

FIG. 8. THE GREAT NEBULA OF ORION, AS PHOTOGRAPHED BY A. A. COMMON WITH A FOUR-FOOT REFLECTOR.

question Herschel, with his usual sagacity, correctly answered in the negative. Up to the time of the spectroscope, all that astronomers could do with nebulæ was to discover, catalogue and describe them.

Several catalogues of these objects have been published. The one long established as a standard is the General Catalogue of Nebulæ and Clusters, by Sir John Herschel. With each object Herschel gave a condensed description. Recently Herschel's catalogue has been superseded by the general catalogue of Dreyer, based upon it.

Some of the more conspicuous of these objects are worthy of being individually mentioned. At the head of all must be placed the great nebula of Orion. This is plainly visible to the naked eye and can be

seen without difficulty whenever the constellation is visible. Note the three bright stars lying nearly in an east and west line and forming the belt of the warrior. South of these will be seen three fainter ones, hanging below the belt, as it were, and forming the sword. To a keen eye, which sharply defines the stars, this middle star will appear hazy. It is the nebula in question. Its character will be strongly brought out by the smallest telescope, even by an opera-glass. Drawings of it have been made by numerous astronomers, the comparison of

FIG. 9. THE GREAT NEBULA OF ANDROMEDA PHOTOGRAPHED BY ROBERTS.

which has given rise to the question whether the object is variable. It cannot be said that this question is yet decided; but the best opinion would probably be in the negative. In recent times the improvements of the photographic process have led to the representation of the object by photography. A photograph made by Mr. A. A. Common, F.R.S., with a reflecting telescope, gives so excellent an impression of the object that by his consent we reproduce it.

The most remarkable feature connected with the nebula of Orion

is the so-called Trapezium, already described. That these four stars form a system by themselves cannot be doubted. The darkness of the nebula immediately around them suggests that they were formed at the expense of the nebulous mass.

Great interest has recently been excited in the spiral form of certain nebulæ The great spiral nebula M. 51 in Canes Venatici has long been known. We reproduce a photograph of this object and another. It is found by recent studies at the Lick Observatory that a spiral form can be detected in a great number of these objects by careful examination.

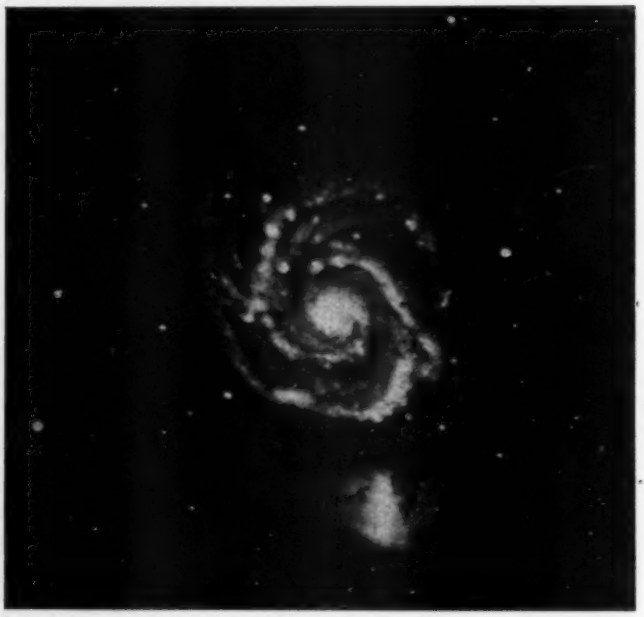

FIG. 10. THE GREAT SPIRAL NEBULA M. 51, AS PHOTOGRAPHED WITH THE CROSSLEY REFLECTOR AT THE LICK OBSERVATORY.

Another striking feature of numerous nebulæ is their varied and fantastic forms, of which we give a number of examples. The 'Triphid nebula' is a noted one in this respect.

The great nebula of Andromeda is second only to that of Orion. It also is plainly visible to the naked eye and can be more readily recognized as a nebula than can the other. It has frequently been mistaken for a comet. Seen through a telescope of high power, its aspect is singular, as if a concealed light were seen shining through horn or semi-transparent glass. It is somewhat elliptical in form, as will be seen from a photograph by Sir William Roberts, F.R.S., which we reproduce (page 19).

Another nebula which, though not conspicuous to the naked eye, has attracted much attention from astronomers, is known, from the figure of one of its branches as the Omega nebula. Sir John Herschel, who first described this object in detail, says of it: "The figure is nearly that of the Greek capital Omega, somewhat distorted and very unequally bright." From one base of the letter extends out to the east a long branch with a hook at the end, which, in most of the drawings, is more conspicuous than the portion included in the Omega. The

FIG. 11. THE GREAT SPIRAL NEBULA M. 33, PHOTOGRAPHED WITH THE CROSSLEY REFLECTOR OF THE LICK OBSERVATORY.

drawings, however, vary so much that the question has been raised whether changes have not taken place in the object. As in other cases, this question is one which it is not yet possible to decide. The appearance of such objects varies so much with the aperture of the telescope and the conditions of vision that it is not easy to decide whether the apparent change may not be due to these causes. It is curious that in a recent photograph the Omega element of it, if I may

use the term, is far less conspicuous than in the older drawings, and is, in fact, scarcely recognizable.

Among the most curious of the nebulæ are the annular ones, which, as the term implies, have the form of a ring. It should be remarked that in such cases the interior of the ring is not generally entirely black, but is filled with nebulous light. We may, therefore, define these objects as nebulæ which are brighter round their circumference than in the center. The most striking of the annular nebulæ is that of Lyra. It may easily be found from being situated about half-way be-

FIG. 12. THE TRIFID NEBULA, PHOTOGRAPHED AT THE LICK OBSERVATORY.

tween the stars Beta and Gamma. Although it is visible in a medium telescope, it requires a powerful one to bring out its peculiar features in a striking way. Recently it has been photographed by Keeler with the Crossley reflector of the Lick Observatory, who found that the best general impression was made with an exposure of only ten minutes.

The ring, as shown by Keeler's photographs, has a quite complicated structure. It seems to be made up of several narrower bright rings, interlacing somewhat irregularly, the spaces between them being filled with fainter nebulosity. One of these rings forms the outer

boundary of the preceding end of the main ring. Sweeping around to the north end of the minor axis, it becomes very bright, perhaps by superposition on the broader main ring of the nebula at this place. It crosses this ring obliquely, forming the brightest part of the whole

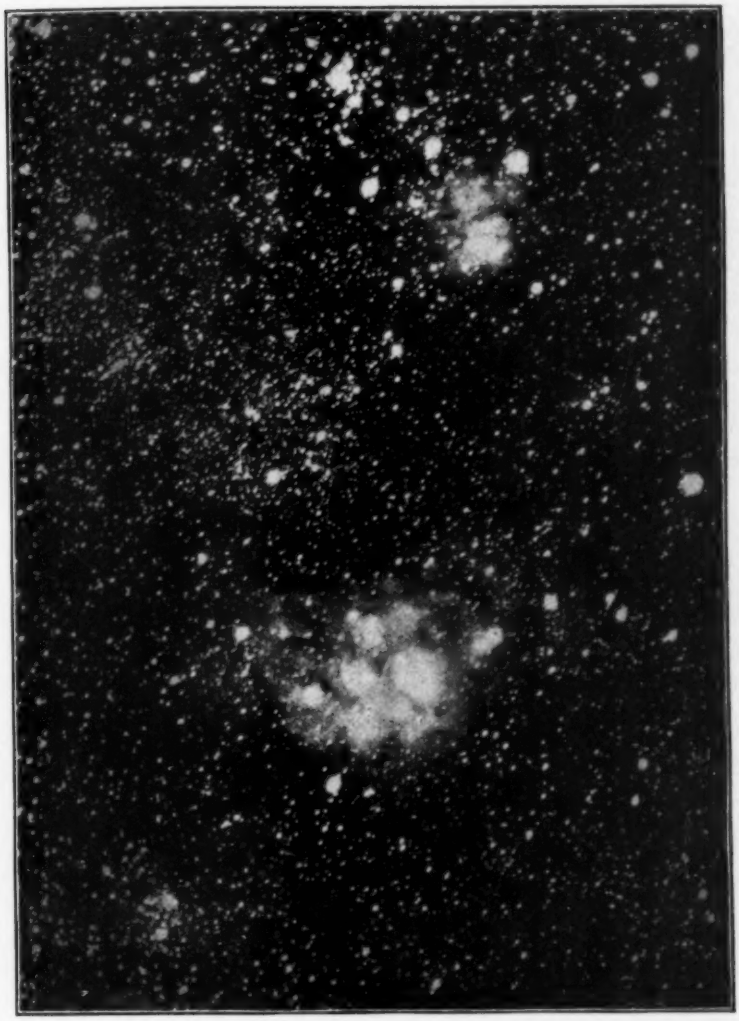

FIG. 13. THE TRIPHID NEBULA AND ITS SURROUNDINGS, AS PHOTOGRAPHED BY BARNARD.

nebula, and then forms the inner boundary of the main ellipse toward its following end. The remaining part of the ring is not so easily traced, as several other rings interlace on the south end of the ellipse.

The central star of this nebula has excited some interest. Its light

seems to have a special actinic power, as the star is more conspicuous on the photographs than to the eye.

There are several other annular nebulæ which are fainter than than of Lyra. The one best visible in our latitudes is known as H IV. 13, or 4,565 of Dreyer's catalogue. It is situated in the constellation Cygnus which adjoins Lyra. Both Herschel and Lord Rosse have made drawings of it. It was photographed by Keeler with the

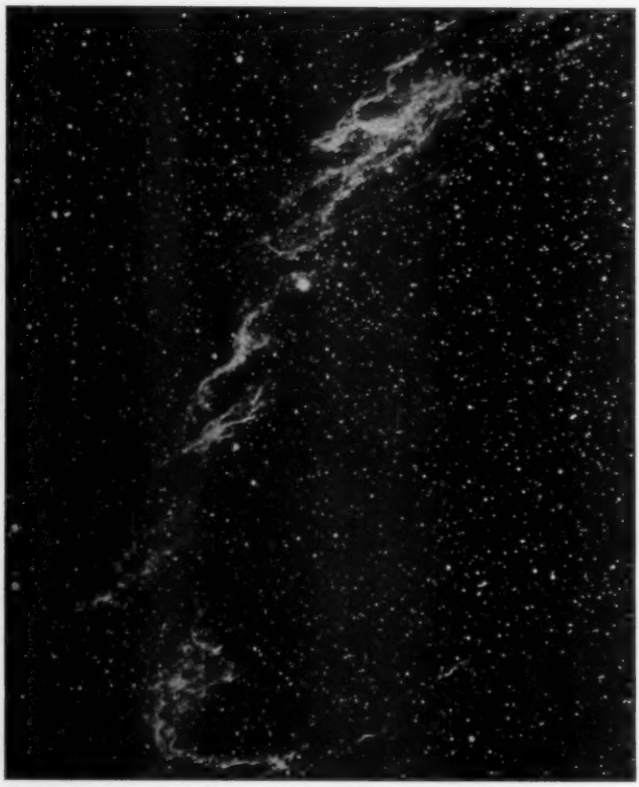

FIG. 14. NEBULOUS MASS IN CYGNUS, INCLUDING H. V. 14 AND H. 2093. PHOTOGRAPHED AT THE LICK OBSERVATORY.

Crossley reflector on the nights of August 9 and 10, 1899, with exposures of one and two hours, respectively. Keeler states that the nebula, as shown by these photographs, "is an elliptical, nearly circular ring, not quite regular in outline, pretty sharply defined at the outer edge." The outside dimensions are:

Major axis	42″.5
Minor axis	40 .5
Position angle of major axis	32°

The nebula has a nucleus with a star exactly in the center. This is very conspicuous on a photograph, but barely if at all visible with a 36-inch reflector.

Another curious class of nebulæ are designated as *planetary*, on account of their form. These consist of minute, round disks of light, having somewhat the appearance of a planet. The appellation was suggested by this appearance. These objects are for the most part faint and difficult.

It is impossible to estimate the number of nebulæ in the heavens. New ones have been from time to time discovered, located and described by many observers during the last thirty years. Among these Lewis Swift is worthy of special mention. On photographing the sky near the galactic pole with the Crossley reflector, Keeler found no less than seven of these objects in a space of about one-half a square degree. He therefore estimates the whole number in the heavens capable of being photographed at several hundred thousand. It may be assumed that only a moderate fraction of these are visible to the eye, even aided by the largest telescopes.

Among the most singular of these objects are large diffused nebulæ, sometimes extending through a region of several degrees. A number of these were discovered by Herschel. Barnard, W. H. Pickering and others have photographed these for us. One of the most remarkable of them winds around in the constellation Orion in such a way that at first sight one might be disposed to inquire whether the impression on the photographic plate might not have been the result of some defect in the apparatus or some reflection of the light of the neighboring stars, which is so apt to occur in these delicate photographic operations. But its existence happens to be completely confirmed by independent testimony. It was first detected by W. H. Pickering and afterwards independently by Barnard.

A curious fact connected with the distribution of nebulæ over the sky is that it is in a certain sense the reverse of that of the stars. The latter are, as we shall hereafter show in detail, vastly more numerous in the regions near the Milky Way and fewer in number near the poles of that belt. But the reverse is the case with the nebulæ proper. They are least numerous in the Milky Way and increase in number as we go from it in either direction. Precisely what this signifies one would not at the present time be able to say. Perhaps the most obvious suggestion would be that in these two opposite nebulous regions the nebulæ have not yet condensed into stars. This, however, would be a purely speculative explanation.

On the other hand, star-clusters are more numerous in the galactic region. This, however, is little more than saying that in the regions where the stars are so much more numerous than elsewhere many of

them naturally tend to collect in clusters. It is, however, a curious fact that, so far as yet been noticed, the large, diffused nebulæ which we have mentioned are more numerous in or near the Milky Way. If this tendency is established it will mark a curious distinction between them and the smaller nebulæ.

The most interesting question connected with these objects is that of their physical constitution. When, about 1866, the spectroscope was applied to astronomical investigation by Huggins and Secchi, these two observers found independently that the light of the great nebula of Orion formed a spectrum of bright lines, thus showing the object to be gaseous. This was soon found to be true of the nebulæ generally. There is, however, a very curious exception in the case of the great nebula of Andromedæ. This object gives a more or less continuous spectrum. Why this is it is difficult to say.

Beyond the general fact that the light of a nebula does not come from solid matter, but from matter of a gaseous or other attenuated form, we have no certain knowledge of the physical constitution of these bodies. Certain features of their constitution can, however, be established with a fair approach to accuracy. Not only the spectroscopic evidence of bright lines, but the aspect of the objects themselves, show that they are transparent through and through. This is remarkable when taken in connection with their inconceivable size. Leaving out the large diffused nebulæ which we have mentioned, these objects are frequently several minutes in diameter. Of their distance we know nothing, except that they are probably situated in the distant stellar regions. Their parallax can be but a small fraction of a second. We shall probably err greatly in excess if we assume that it varies between one-hundredth and one-tenth of a second. To assign this parallax is the same thing as saying that at the distance of the nebulæ the dimensions of the earth's orbit would show a diameter which might range between one-fiftieth and one-fifth of a second, while that of Neptune would be more or less than one second. Great numbers of these objects are, therefore, thousands of times the dimensions of the earth's orbit, and probably most of them are thousands of times the dimensions of the whole solar system. That they should be completely transparent through such enormous dimensions shows their extreme tenuity. Were our solar system placed in the midst of one of them, it is probable that we should not be able to find any evidence of its existence.

A form of matter so different from any that can be found or produced on the surface of the earth can hardly be explained by our ordinary views of matter. A theory has, however, been propounded by Sir Norman Lockyer, so ingenious as to be worthy at least of mention. It is that these objects are vast collections of meteorites in rapid motion

relatively to each other, which come into constant collision. Their velocity is such that at each collision heat and light are produced. In the language of our progenitors, who in the absence of matches used flint and steel, they 'strike fire' against each other. The idea of such a process originated with Prof. P. G. Tait, in an attempt to explain the tail of a comet, but it was elaborated and developed by Mr. Lockyer in his work on the 'Meteoritic Theory.'

The objections to this theory seem insuperable. A velocity so great, at such a distance from the center of the nebulæ, would be incompatible with the extreme tenuity of these objects. Every time that two meteors came into collision they would lose velocity, and, therefore, if the mass was sufficient to hold them from flying through space, would rapidly fall toward a common center. The amount of light produced by the collision of two such objects is only a minute fraction of the energy lost. The meteors which fall on the earth are mostly of iron, and, were the theory true, numerous lines of iron should be most conspicuous in the spectrum. But the fact is that in the great number of these objects there is but a single bright line, which does not seem to correspond to the line of any known substance. The supposed matter which produces it has, therefore, been called *nebulum*.

RAPID BATTLESHIP BUILDING.

By WALDON FAWCETT.

A VARIETY of influences, aside from the occasional exigencies of actual war conditions, have, during the past few years, combined to force upon naval architects and shipbuilders a conviction of the need for more expeditious work in the construction of war vessels, and especially of battleships. As the modern fighting vessel has grown in weight and complexity of design, the interval necessitated for its construction has very naturally been lengthened. That this condition of affairs would sooner or later induce a sentiment of dissatisfaction was the more certain from the fact that throughout the world many government officers have to do with the construction and operation of naval flotilla who are inadequately informed regarding technical details.

The feeling of impatience on account of the time occupied in building a battleship has, of course, disclosed itself first of all to the shipbuilder, and the practical men of the industry have already set themselves to remedy the conditions in so far as it is possible. How much has been accomplished in a comparatively brief space of time is eloquently attested by the records for time economy in battleship construction which have been made during the past two years, particularly in British and American yards.

Although the shipbuilder has been able to accomplish much by the introduction of improved tools and machinery, with the attendant speedier methods of handling material, he is becoming more and more an advocate of the simplification of the battleship. His contentions are receiving the indorsement of many naval constructors of ability and experience, who are impressed by the advisability of reducing the cost of single ships, on the theory of the old adage against placing all the eggs in one basket. Protests have been directed particularly against the complication and multiplying diversity of function sought by mechanical contrivances, but of late there have been on the part of naval architects many expressions of opinion to the effect that the auxiliaries are not the only features of a battleship which might be modified with profit.

As was stated above, it is the shipbuilder who has first been brought to a realization of the fact that he must keep pace with modern progress by constant reductions of the time necessary to turn out a complete armor-clad. Thus the William Cramp & Sons Ship and Engine Building Company, of Philadelphia, has recently secured a contract from the

Russian government for the construction of a battleship and a cruiser, largely from the fact that they were able to guarantee delivery within thirty-three months, whereas the French builders who made tenders for the contract could not promise the completion of the vessels much under five years.

Some of the most remarkable records in the reduction of the time between the laying of a keel and the launching of a vessel have been made in British shipyards. Notable in this respect was the battleship 'Bulwark,' which was launched at the Davenport dockyard on October 18, 1899. This vessel was laid down on March 20, 1899, and had thus been under construction less than seven months. During that time

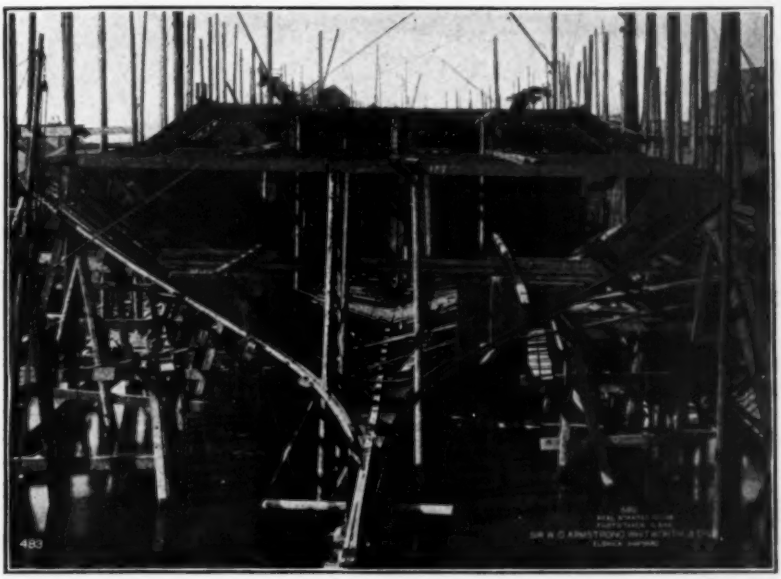

FIG. 1. THE BATTLESHIP 'HATSUSE' THREE MONTHS AFTER THE KEEL HAD BEEN LAID.

5,450 tons of material had been built into her, and there is nothing to controvert the assertions of the dockyard staff that the work created records in both the time she had been under construction and the weight attained for the period. In order to convey a better idea of the work accomplished it may be noted in passing that the 'Bulwark' is 400 feet in length between perpendiculars, 75 feet beam, 27 feet draught and 15,000 tons displacement.

The British builders have for some time past made rapidity of construction a subject of study, and their more recent achievements have been attained as the culmination of a series of performances only slightly less creditable. Thus, but nine months and nine days inter-

vened between the dates of laying the keel and launching the battleship 'Canopas', a vessel of 12,590 tons displacement, and even then the work was delayed by a strike. The cruiser 'Diadem', a sheathed vessel of 11,000 tons displacement and 16,500 horse-power, was built by the Fairfield Shipbuilding and Engineering Company, Limited, of Govan, Scotland, in 214 working days, and moreover, the vessel was fitted, before launching, with all her armor casements.

The battleship 'Majestic' of the British navy was launched complete and ready to go into commission, and this vessel went into the water just twenty-two months from the date of the laying of the keel. An even two years was required for the completion of the 'Magnificent,'

FIG. 2. THE BATTLESHIP 'HATSUSE' AFTER ABOUT FOUR AND A HALF MONTHS, SHOWING THE PROTECTIVE DECK.

another battleship of the same class. A record almost equal to that of the 'Bulwark' was that of the battleship 'Prince George', the displacement of which is 14,900 tons. This vessel was built and launched in eleven months. For purposes of comparison, the fact may be cited that Laird Brothers, of Birkenhead, built the torpedo-boat destroyer 'Sparrow Hawk', a vessel which attained a speed in the neighborhood of thirty knots on trial, in the space of one hundred days.

Taking into consideration, however, all influencing conditions, the records made since the beginning of 1899 indicate a distinct advance on the part of the builders. The Thames Iron Works, Shipbuilding and Engineering Company, of Blackwall, made an excellent showing with

the British battleship 'Venerable', which was christened early in November, 1899. This vessel was laid down in the first week of January, 1899, and her construction proceeded at such a rate that it was possible to place her in the water in exactly ten months from the day on which her first keel plate was laid. In this case the builders were impelled not so much by a desire to establish a record, as to provide a slip for the commencement of work on another naval contract.

It is a singular coincidence that the most favorable records established thus far in the annals of naval ship-building should have been made by three sister vessels, the trio being among the largest battle-

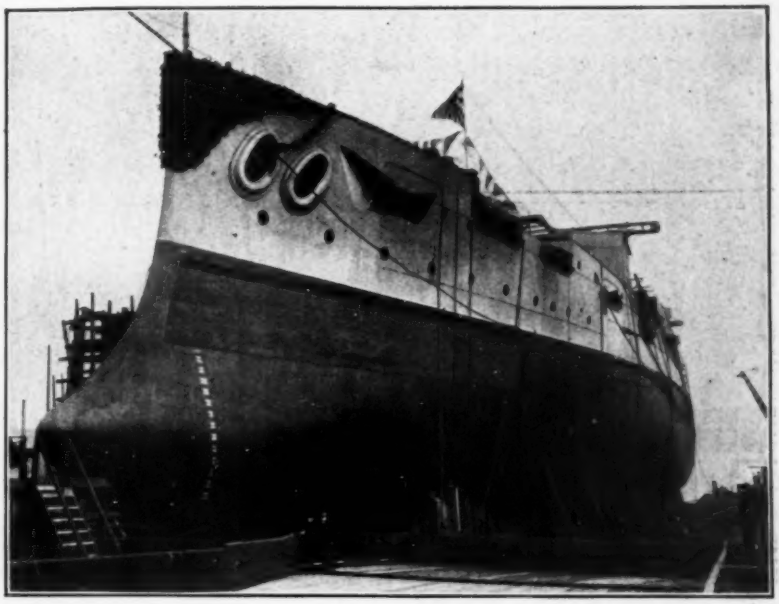

FIG. 3. THE BATTLESHIP 'HATSUSE' READY FOR LAUNCHING.

ships in the world. The performances of the 'Bulwark' and 'Venerable' have already been noted. That of the 'London' is scarcely less creditable. This vessel was built at the Portsmouth dockyard and was laid down on December 8, 1898. She was thus under construction a little more than nine months, and during that time over five thousand tons of material were built into her.

That all the energies of the builders of the United Kingdom are not exerted in behalf of their own nation is attested by the showing made by the Thames Iron Works, Shipbuilding and Engineering Company in the case of the battleship 'Shikishima', completed during the early part of 1899 for the Japanese government. The first plate of this

vessel was laid down on May 1, 1897, and although the engineers' strike resulted in a delay of more than six months in the delivery of armor, armament and engines, the trials of the vessel were completed to the satisfaction of all parties concerned, and the 'Shikishima' was turned over to her owners in less than twenty-nine months from the date above given for the commencement of the work. In its way this achievement also constitutes a record which has had no parallel, and certainly the fact that despite detrimental circumstances a vessel of 15,000 tons displacement and 19 knots speed can be built, equipped, armored, engined and

FIG. 4. THE LAUNCHING OF THE BATTLESHIP 'HATSUSE,' JUNE 27, 1899.

tested under actual service conditions, all in little more than two years' time, speaks well for modern engineering methods.

The loss of the Russian contracts previously referred to—and other circumstances—have seemingly made some impression on French shipbuilders, and a shortening of the time consumed in some of the principal yards has already been made. For instance, it is announced that should nothing unforeseen intervene, the first-class battleship 'Suffren'. which

was launched at Brest on July 25, 1899, will be completed by July, 1901. Should this promise be fulfilled the time consumed in the construction of the vessel will be little more than thirty-one months, which is considerably less than for any French battleship previously constructed. It must also be remembered that the 'Suffren' is the largest battleship yet designed for the French navy, her displacement being 12,728 tons. In some respects, the 'Suffren' outranks the British vessel, as but six months and twenty days elapsed between the laying down of the keel and the launching.

Neither Germany nor the United States can show records to compare with those of the British builders, despite the expeditious delivery of merchant vessels which has been made by firms in both countries. The United States has now several plants capable of building and launching a battleship in an interval very nearly as brief as the best of those above recorded, but American builders have been so retarded ever since bringing their plants to the present stage of efficiency by difficulty in securing prompt delivery of armor and other material that the possibility of making records has been precluded, and, indeed, it is not strange if under the circumstances there has been small ambition to make the endeavor.

The photographs herewith reproduced as illustrative of the building of a battleship represent the 'Hatsuse', which was launched during the summer of 1899 at the Elswick shipyard of Sir W. G. Armstrong, Whitworth & Co., of Newcastle-on-Tyne, England, the builders of the cruisers 'Albany' and 'New Orleans', the only foreign-built war vessels of any considerable size in the American navy. The 'Hatsuse' is a battleship of the largest size, and represents in every respect the most modern practice. She is 400 feet in length, 76½ feet beam, 27 feet draught of water and 15,000 tons displacement. Her engines are capable of developing 14,500 indicated horse-power.

The first photograph was taken about three months after the keel had been laid. It shows the framing of the extreme end of the vessel, with three tires of beams in view.

The second picture in the series, taken about six weeks later, looking aft from about amidships, shows the after barbette about half constructed, while the protective deck is practically completed. The third view represents the vessel ready for launching, and the fourth and last depicts the launch on June 27, 1899. In conclusion, it may be noted that the 'Hatsuse', the launching weight of which was fully 8,000 tons, went down the ways several minutes before the appointed time.

ADDRESS OF THE PRESIDENT BEFORE THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

By Sir WILLIAM TURNER, F. R. S.

II.

FUNCTION OF CELLS.

IT has already been stated that, when new cells arise within pre-existing cells, division of the nucleus is associated with cleavage of the cell plasm, so that it participates in the process of new cell-formation. Undoubtedly, however, its rôle is not limited to this function. It also plays an important part in secretion, nutrition and the special functions discharged by the cells in the tissues and organs of which they form morphological elements.

Between 1838 and 1842 observations were made which showed that cells were constituent parts of secreting glands and mucous membranes (Schwann, Henle). In 1842 John Goodsir communicated to the Royal Society of Edinburgh a memoir on secreting structures, in which he established the principle that cells are the ultimate secreting agents; he recognized in the cells of the liver, kidney and other organs the characteristic secretion of each gland. The secretion was, he said, situated between the nucleus and the cell wall. At first he thought that, as the nucleus was the reproductive organ of the cell, the secretion was formed in the interior of the cell by the agency of the cell wall; but three years later he regarded it as a product of the nucleus. The study of the process of spermatogenesis by his brother, Harry Goodsir, in which the head of the spermatozoon was found to correspond with the nucleus of the cell in which the spermatozoon arose, gave support to the view that the nucleus played an important part in the genesis of the characteristic product of the gland cell.

The physiological activity of the cell plasm and its complex chemical constitution soon after began to be recognized. Some years before Max Schultze had published his memoirs on the characters of protoplasm, Brücke had shown that the well-known changes in tint in the skin of the chameleon were due to pigment granules situated in cells in the skin which were sometimes diffused throughout the cells, at others concentrated in the center. Similar observations on the skin of the frog were made in 1854 by von Wittich and Harless. The movements were regarded as due to contraction of the cell wall on its contents. In a most interesting paper on the pigmentary system in the frog, pub-

lished in 1858, Lord Lister demonstrated that the pigment granules moved in the cell plasma, by forces resident within the cell itself, acting under the influence of an external stimulant, and not by a contractility of the wall. Under some conditions the pigment was attracted to the center of the cell, when the skin became pale; under other conditions the pigment was diffused throughout the body and the branches of the cell, and gave to the skin a dark color. It was also experimentally shown that a potent influence over these movements was exercised by the nervous system.

The study of the cells of glands engaged in secretion, even when the secretion is colorless, and the comparison of their appearance when secretion is going on with that seen when the cells are at rest, have shown that the cell plasm is much more granular and opaque, and contains larger particles during activity than when the cell is passive; the body of the cell swells out from an increase in the contents of its plasm, and chemical changes accompany the act of secretion. Ample evidence, therefore, is at hand to support the position taken by John Goodsir, nearly sixty years ago, that secretions are formed within the cells, and lie in that part of the cell which we now say consists of the cell plasm; that each secreting cell is endowed with its own peculiar property, according to the organ in which it is situated, so that bile is formed by the cells in the liver, milk by those in the mamma, and so on.

Intimately associated with the process of secretion is that of nutrition. As the cell plasm lies at the periphery of a cell, and as it is, alike both in secretion and nutrition, brought into closest relation with the surrounding medium, from which the pabulum is derived, it is necessarily associated with nutritive activity. Its position enables it to absorb nutritive material directly from without, and in the process of growth it increases in amount by interstitial changes and additions throughout its substance, and not by mere accretions on its surface.

Hitherto I have spoken of a cell as a unit, independent of its neighbors as regards its nutrition and the other functions which it has to discharge. The question has, however, been discussed, whether in a tissue composed of cells closely packed together cell plasm may not give origin to processes or threads which are in contact or continuous with corresponding processes of adjoining cells, and that cells may therefore, to some extent, lose their individuality in the colony of which they are members. Appearances were recognized between 1863 and 1870 by Schrön and others in the deeper cells of the epidermis and of some mucous membranes which gave sanction to this view, and it seems possible, through contact or continuity of threads connecting a cell with its neighbors, that cells may exercise a direct influence on each other.

Nägeli, the botanist, as the foundation of a mechanico-physiological theory of descent, considered that in plants a network of cell plasm,

named by him idio-plasm, extended throughout the whole of the plant, forming its specific molecular constitution, and that growth and activity were regulated by its conditions of tension and movements (1884).

The study of the structure of plants, with special reference to the presence of an intercellular network, has for some years been pursued by Walter Gardiner (1882-97), who has demonstrated threads of cell plasm protruding through the walls of vegetable cells and continuous with similar threads from adjoining cells. Structurally, therefore, a plant may be conceived to be built up of a nucleated cytoplasmic network, each nucleus with the branching cell plasm surrounding it being a center of activity. On this view a cell would retain to some extent its individuality, though, as Gardiner contends, the connecting threads would be the medium for the conduction of impulses and of food from a cell to those which lie around it. For the plant cell, therefore, as has long been accepted in the animal cell, the wall is reduced to a secondary position, and the active constituent is the nucleated cell plasm. It is not unlikely that the absence of a controlling nervous system in plants requires the plasm of adjoining cells to be brought into more immediate contact and continuity than is the case with the generality of animal cells, so as to provide a mechanism for harmonizing the nutritive and other functional processes in the different areas in the body of the plant. In this particular, it is of interest to note that the epithelial tissues in animals, where somewhat similar connecting arrangements occur, are only indirectly associated with the nervous and vascular systems, so that, as in plants, the cells may require, for nutritive and other purposes, to act and react directly on each other.

NERVE CELLS.

Of recent years great attention has been paid to the intimate structure of nerve cells, and to the appearance which they present when in the exercise of their functional activity. A nerve cell is not a secreting cell—that is, it does not derive from the blood or surrounding fluid a pabulum which it elaborates into a visible, palpable secretion characteristic of the organ of which the cell is a constituent element, to be in due course discharged into a duct which conveys the secretion out of the gland. Nerve cells, through the metabolic changes which take place in them, in connection with their nutrition, are associated with the production of the form of energy specially exhibited by animals which possess a nervous system, termed nerve energy. It has long been known that every nerve cell has a body in which a relatively large nucleus is situated. A most important discovery was the recognition that the body of every nerve cell had one or more processes growing out from it. More recently it has been proved, chiefly through the researches of Schultze, His, Golgi and Ramon y Cajal, that at least one of the pro-

cesses, the axon of the nerve cell, is continued into the axial cylinder of a nerve fiber, and that in the multipolar nerve cell the other processes, or dendrites, branch and ramify for some distance away from the body. A nerve fiber is, therefore, an essential part of the cell with which it is continuous, and the cell, its processes, the nerve fiber and the collaterals which arise from the nerve fiber collectively form a neuron or structural nerve unit (Waldeyer). The nucleated body of the nerve cell is the physiological center of the unit.

The cell plasm occupies both the body of the nerve cell and its processes. The intimate structure of the plasm has, by improved methods of observation introduced during the last eight years by Nissl, and conducted on similar lines by other investigators, become more definitely understood. It has been ascertained that it possesses two distinct characters which imply different structures. One of these stains deeply on the addition of certain dyes, and is named chromophile or chromatic substance; the other, which does not possess a similar property, is the achromatic network. The chromophile is found in the cell body and the dendritic processes, but not in the axon. It occurs in the form of granular particles, which may be scattered throughout the plasm, or aggregated into little heaps which are elongated or fusiform in shape and appear as distinct colored particles or masses. The achromatic network is found in the cell body and the dendrites, and is continued also in the axon, where it forms the axial cylinder of the nerve fiber. It consists apparently of delicate threads or fibrillæ, in the meshes of which a homogeneous material, such as is found in cell plasm generally, is contained. In the nerve cells, as in other cells, the plasm is without doubt concerned in the process of cell nutrition. The achromatic fibrillæ exercise an important influence on the axon or nerve fiber with which they are continuous, and probably they conduct the nerve impulses which manifest themselves in the form of nerve energy. The dendritic processes of a multipolar nerve cell ramify in close relation with similar processes branching from other cells in the same group. The collaterals and the free end of the axon fiber process branch and ramify in association with the body of a nerve cell or of its dendrites. We cannot say that these parts are directly continuous with each other to form an intercellular network, but they are apparently in apposition, and through contact exercise influence one on the other in the transmission of nerve impulses.

There is evidence to show that in the nerve cell the nucleus, as well as the cell plasm, is an effective agent in nutrition. When the cell is functionally active, both the cell body and the nucleus increase in size (Vas, G. Mann, Lugaro); on the other hand, when nerve cells are fatigued through excessive use, the nucleus decreases in size and shrivels; the cell plasm also shrinks, and its colored or chromophile con-

stituent becomes diminished in quantity, as if it had been consumed during the prolonged use of the cell (Hodge, Mann, Lugaro). It is interesting also to note that in hibernating animals in the winter season, when their functional activity is reduced to a minimum, the chromophile in the plasm of the nerve cells is much smaller in amount than when the animal is leading an active life in the spring and summer (G. Levi).

When a nerve cell has attained its normal size it does not seem to be capable of reproducing new cells in its substance by a process of karyokinesis, such as takes place when young cells arise in the egg and in the tissues generally. It would appear that nerve cells are so highly specialized in their association with the evolution of nerve energy, that they have ceased to have the power of reproducing their kind, and the metabolic changes, both in cell plasm and nucleus, are needed to enable them to discharge their very peculiar function. Hence it follows that when a portion of the brain or other nerve-center is destroyed, the injury is not repaired by the production of fresh specimens of their characteristic cells, as would be the case in injuries to bones and tendons.

In our endeavors to differentiate the functions of the nucleus from that of the cell plasm, we should not regard the former as concerned only in the production of young cells, and the latter as the exclusive agent in growth, nutrition and, where gland cells are concerned, in the formation of their characteristic products. As regards cell reproduction also, though the process of division begins in the nucleus in its chromosome constituents, the achromatic figure in the cell plasm undoubtedly plays a part, and the cell plasm itself ultimately undergoes cleavage.

A few years ago the tendency amongst biologists was to ignore or attach but little importance to the physiological use of the nucleus in the nucleated cell, and to regard the protoplasm as the essential and active constituent of living matter; so much so, indeed, was this the case that independent organisms regarded as distinct species were described as consisting of protoplasm destitute of a nucleus; also, that scraps of protoplasm separated from larger nucleated masses could, when isolated, exhibit vital phenomena. There is reason to believe that a fragment of protoplasm, when isolated from the nucleus of a cell, though retaining its contractility, and capable of nourishing itself for a short time, cannot increase in amount, act as a secreting structure, or reproduce its kind: it soon loses its activity, withers and dies. In order that these qualities of living matter should be retained, a nucleus is by most observers regarded as necessary (Nussbaum, Gruber, Haberlandt, Korschelt), and for the complete manifestation of vital activity both nucleus and cell plasm are required.

BACTERIA.

The observations of Cohn, made about thirty years ago, and those of De Bary shortly afterwards, brought into notice a group of organisms to which the name 'bacterium' or 'microbe' is given. They were seen to vary in shape; some were rounded specks called cocci, others were straight rods called bacilli, others were curved or spiral rods, vibrios or spirillæ. All were characterized by their extreme minuteness, and required for their examination the highest powers of the best microscopes. Many bacteria measure in their least diameter not more than $\frac{1}{2500}$ of an inch, $\frac{1}{10}$ the diameter of a human white blood corpuscle. Through the researches of Pasteur, Lord Lister, Koch and other observers, bacteria have been shown to play an important part in nature. They exercise a very remarkable power over organic substances, especially those which are complex in chemical constitution, and can resolve them into simpler combinations. Owing to this property, some bacteria are of great economic value, and without their agency many of our industries could not be pursued; others again, and these are the most talked of, exercise a malign influence in the production of the most deadly diseases which afflict man and the domestic animals.

Great attention has been given to the structure of bacteria and to their mode of propagation. When examined in the living state and magnified about 2,000 times, a bacterium appears as a homogeneous particle, with a sharp definite outline, though a membranous envelope or wall, distinct from the body of the bacterium, cannot at first be recognized; but when treated with reagents a membranous envelope appears, the presence of which, without doubt, gives precision of form to the bacterium. The substance within the membrane contains granules which can be dyed with coloring agents. Owing to their extreme minuteness it is difficult to pronounce an opinion on the nature of the chromatine granules and the substance in which they lie. Some observers regard them as nuclear material, invested by only a thin layer of protoplasm, on which view a bacterium would be a nucleated cell. Others consider the bacterium as formed of protoplasm containing granules capable of being colored, which are a part of the protoplasm itself, and not a nuclear substance. On the latter view, bacteria would consist of cell plasm enclosed in a membrane and destitute of a nucleus. Whatever be the nature of the granule-containing material, each bacterium is regarded as a cell, the minutest and simplest living particle capable of an independent existence that has yet been discovered.

Bacteria cells, like cells generally, can reproduce their kind. They multiply by simple fission, probably with an ingrowth of the cell wall, but without the karyokinetic phenomena observed in nucleated cells. Each cell gives rise to two daughter cells, which may for a time remain

attached to each other and form a cluster or a chain, or they may separate and become independent isolated cells. The multiplication, under favorable conditions of light, air, temperature, moisture and food, goes on with extraordinary rapidity, so that in a few hours many thousand new individuals may arise from a parent bacterium.

Connected with the life-history of a bacterium cell is the formation in its substance, in many species and under certain conditions, of a highly refractile shiny particle called a spore. At first sight a spore seems as if it were the nucleus of the bacterium cell, but it is not always present when multiplication by cleavage is taking place, and when present it does not appear to take part in the fission. On the other hand, a spore, from the character of its envelope, possesses great power of resistance, so that dried bacteria, when placed in conditions favorable to germination, can through their spores germinate and resume an active existence. Spore formation seems, therefore, to be a provision for continuing the life of the bacterium under conditions which, if spores had not formed, would have been the cause of its death.

The time has gone by to search for the origin of living organisms by a spontaneous aggregation of molecules in vegetable or other infusions, or from a layer of formless primordial slime diffused over the bed of the ocean. Living matter during our epoch has been, and continues to be, derived from pre-existing living matter, even when it possesses the simplicity of structure of a bacterium, and the morphological unit is the cell.

DEVELOPMENT OF THE EGG.

As the future of the entire organism lies in the fertilized egg cell, we may now briefly review the arrangements, consequent on the process of segmentation, which lead to the formation, let us say in the egg of a bird, of the embryo or young chick.

In the latter part of the last century, C. F. Wolff observed that the beginning of the embryo was associated with the formation of layers, and in 1817 Pander demonstrated that in the hen's egg at first one layer, called mucous, appeared; then a second or serous layer, to be followed by a third, intermediate or vascular layer. In 1828 von Baer amplified our knowledge in his famous treatise, which from its grasp of the subject created a new epoch in the science of embryology. It was not, however, until the discovery by Schwann of cells as constant factors in the structure of animals and in their relation to development that the true nature of these layers was determined. We now know that each layer consists of cells, and that all the tissues and organs of the body are derived from them. Numerous observers have devoted themselves for many years to the study of each layer, with the view of determining the part which it takes in the formation of the constituent parts of the body, more es-

pecially in the higher animals, and the important conclusion has been arrived at that each kind of tissue invariably arises from one of these layers and from no other.

The layer of cells which contributes, both as regards the number and variety of the tissues derived from it, most largely to the formation of the body is the middle layer, or mesoblast. From it the skeleton, the muscles and other locomotor organs, the true skin, the vascular system, including the blood, and other structures which I need not detail, take their rise. From the inner layer of cells the principal derivatives are the epithelial linings of the alimentary canal and of the air passages. The outer layer of cells gives origin to the epidermis or scarf skin, and to the nervous system. It is interesting to note that from the same layer of the embryo arise parts so different in importance as the cuticle—a mere protecting structure, which is constantly being shed when the skin is subjected to the friction of a towel or the clothes—and the nervous system, including the brain, the most highly differentiated system in the animal body. How completely the cells from which they are derived had diverged from each other in the course of their differentiation in structure and properties is shown by the fact that the cells of the epidermis are continually engaged in reproducing new cells to replace those which are shed, whilst the cells of the nervous system have apparently lost the power of reproducing their kind.

In the early stage of the development of the egg, the cells in a given layer resemble each other in form, and, as far as can be judged from their appearance, are alike in structure and properties. As the development proceeds, the cells begin to show differences in character, and in the course of time the tissues which arise in each layer differentiate from each other and can be readily recognized by the observer. To use the language of von Baer, a generalized structure has become specialized, and each of the special tissues produced exhibits its own structure and properties. These changes are coincident with a rapid multiplication of the cells by cleavage, and thus increase in size of the embryo accompanies specialization of structure. As the process continues, the embryo gradually assumes the shape characteristic of the species to which its parents belonged, until at length it is fit to be born and to assume a separate existence.

The conversion of cells, at first uniform in character, into tissues of a diverse kind, is due to forces inherent in the cells in each layer. The cell plasm plays an active, though not an exclusive part in the specialization; for as the nucleus influences nutrition and secretion, it acts as a factor in the differentiation of the tissues. When tissues so diverse in character as muscular fiber, cartilage, fibrous tissues and bone arise from the cells of the middle or mesoblast layer, it is obvious that, in addition to the morphological differentiation affecting form and struc-

ture, a chemical differentiation affecting composition also occurs, as the result of which a physiological differentiation takes place. The tissues and organs become fitted to transform the energy derived from the food into muscular energy, nerve energy and other forms of vital activity. Corresponding differentiations also modify the cells of the outer and inner layers. Hence the study of the development of the generalized cell layers in the young embryo enables us to realize how all the complex constituent parts of the body in the higher animals and in man are evolved by the process of differentiation from a simple nucleated cell—the fertilized ovum. A knowledge of the cell and of its life-history is, therefore, the foundation stone on which biological science in all its departments is based.

If we are to understand by an organ in the biological sense a complex body capable of carrying on a natural process, a nucleated cell is an organ in its simplest form. In a unicellular animal or plant, such an organ exists in its most primitive stage. The higher plants and animals again are built up of multitudes of these organs, each of which, whilst having its independent life, is associated with the others, so that the whole may act in unison for a common purpose. As in one of your great factories each spindle is engaged in twisting and winding its own thread, it is at the same time intimately associated with the hundreds of other spindles in its immediate proximity, in the manufacture of the yarn, from which the web of cloth is ultimately to be woven.

It has taken more than fifty years of hard and continuous work to bring our knowledge of the structure and development of the tissues and organs of plants and animals up to the level of the present day. Amidst the host of names of investigators, both at home and abroad, who have contributed to its progress, it may seem invidious to particularize individuals. There are, however, a few that I cannot forbear to mention, whose claim to be named on such an occasion as this will be generally conceded.

Botanists will, I think, acknowledge Wilhelm Hofmeister as a master in morphology and embryology; Julius von Sachs as the most important investigator in vegetable physiology during the last quarter of a century, and Strasburger as a leader in the study of the phenomena of nuclear division.

The researches of the veteran professor of anatomy in Würzburg, Albert von Kölliker, have covered the entire field of animal histology. His first paper, published fifty-nine years ago, was followed by a succession of memoirs and books on human and comparative histology and embryology, and culminated in his great treatise on the structure of the brain, published in 1896. Notwithstanding the weight of more than eighty years, he continues to prosecute histological research, and has

published the results of his latest, though let us hope not his last, work during the present year.

Amongst our countrymen, and belonging to the generation which has almost passed away, was William Bowman. His investigations between 1840 and 1850 on the mucous membranes, muscular fiber and the structure of the kidney, together with his researches on the organs of sense, were characterized by a power of observation and of interpreting difficult and complicated appearances which has made his memoirs on these subjects landmarks in the history of histological inquiry.

Of the younger generation of biologists, Francis Maitland Balfour, whose early death is deeply deplored as a loss to British science, was one of the most distinguished. His powers of observation and philosophic perception gave him a high place as an original inquirer, and the charm of his personality—for charm is not the exclusive possession of the fairer sex—endeared him to his friends.

GENERAL MORPHOLOGY.

Along with the study of the origin and structure of the tissues of organized bodies, much attention has been given during the century to the parts or organs in plants and animals, with the view of determining where and how they take their rise, the order of their formation, the changes which they pass through in the early stages of development and their relative positions in the organism to which they belong. Investigations on these lines are spoken of as morphological, and are to be distinguished from the study of their physiological or functional relations, though both are necessary for the full comprehension of the living organism.

The first to recognize that morphological relations might exist between the organs of a plant, dissimilar as regards their function, was the poet, Goethe, whose observations, guided by his imaginative faculty, led him to declare that the calyx, corolla and other parts of a flower, the scales of a bulb, etc., were metamorphosed leaves, a principle generally accepted by botanists, and, indeed, extended to other parts of a plant, which are referred to certain common morphological forms, although they exercise different functions. Goethe also applied the same principle in the study of the skeletons of vertebrate animals, and he formed the opinion that the spinal column and the skull were essentially alike in construction, and consisted of vertebræ, an idea which was also independently conceived and advocated by Oken.

The anatomist who in our country most strenuously applied himself to the morphological study of the skeleton was Richard Owen, whose knowledge of animal structure, based upon his own dissections, was unrivaled in range and variety. He elaborated the conception of an ideal,

archetype vertebrate form which had no existence in nature, and to which, subject to modifications in various directions, he considered all vertebrate skeletons might be referred. Owen's observations were conducted to a large extent on the skeletons of adult animals, of the knowledge of which he was a master. As in the course of development modifications in shape and in the relative position of parts not unfrequently occur, and their original character and place of origin become obscured, it is difficult, from the study only of adults, to arrive at a correct interpretation of their morphological significance. When the changes which take place in the skull during its development, as worked out by Reichert and Rathke, became known and their value had become appreciated, many of the conclusions arrived at by Owen were challenged and ceased to be accepted. It is, however, due to that eminent anatomist to state from my personal knowledge of the condition of anatomical science in this country fifty years ago, that an enormous impulse was given to the study of comparative morphology by his writings, and by the criticisms to which they were subjected.

There can be no doubt that generalized arrangements do exist in the early embryo which, up to a certain stage, are common to animals that in their adult condition present diverse characters, and out of which the forms special to different groups are evolved. As an illustration of this principle, I may refer to the stages of development of the great arteries in the bodies of vertebrate animals. Originally, as the observations of Rathke have taught us, the main arteries are represented by pairs of symmetrically arranged vascular arches, some of which enlarge and constitute the permanent arteries in the adult, whilst others disappear. The increase in size of some of these arches, and the atrophy of others, are so constant for different groups that they constitute anatomical features as distinctive as the modifications in the skeleton itself. Thus in mammals the fourth vascular arch on the left side persists, and forms the arch of the aorta; in birds the corresponding part of the aorta is an enlargement of the fourth right arch, and in reptiles both arches persist to form the great artery. That this original symmetry exists also in man we know from the fact that now and again his body, instead of corresponding with the mammalian type, has an aortic arch like that which is natural to the bird, and in rarer cases even to the reptile. A type form common to the vertebrata does, therefore, in such cases exist, capable of evolution in more than one direction.

The reputation of Thomas Henry Huxley as a philosophic comparative anatomist rests largely on his early perception of, and insistence on, the necessity of testing morphological conclusions by a reference to the development of parts and organs, and by applying this principle in his own investigations. The principle is now so generally accepted by both botanists and anatomists that morphological definitions are regarded as

depending essentially on the successive phases of the development of the parts under consideration.

The morphological characters exhibited by a plant or animal tend to be hereditarily transmitted from parents to offspring, and the species is perpetuated. In each species the evolution of an individual, through the developmental changes in the egg, follows the same lines in all the individuals of the same species, which possess, therefore, in common, the features called specific characters. The transmission of these characters is due, according to the theory of Weismann, to certain properties possessed by the chromosome constituents of the segmentation nucleus in the fertilized ovum, named by him the germ plasm, which is continued from one generation to another, and impresses its specific character on the egg and on the plant or animal developed from it.

As has already been stated, the special tissues which build up the bodies of the more complex organisms are evolved out of cells which are at first simple in form and appearance. During the evolution of the individual, cells become modified or differentiated in structure and function, and so long as the differentiation follows certain prescribed lines the morphological characters of the species are preserved. We can readily conceive that, as the process of specialization is going on, modifications or variations in groups of cells and the tissues derived from them, notwithstanding the influence of heredity, may in an individual diverge so far from that which is characteristic of the species as to assume the arrangements found in another species, or even in another order. Anatomists had, indeed, long recognized that variations from the customary arrangement of parts occasionally appeared, and they described such deviations from the current descriptions as irregularities.

DARWINIAN THEORY.

The signification of the variations which arise in plants and animals had not been apprehended until a flood of light was thrown on the entire subject by the genius of Charles Darwin, who formulated the wide-reaching theory that variations could be transmitted by heredity to younger generations. In this manner he conceived new characters would arise, accumulate and be perpetuated, which would in the course of time assume specific importance. New species might thus be evolved out of organisms originally distinct from them, and their specific characters would in turn be transmitted to their descendants. By a continuance of this process new species would multiply in many directions, until at length, from one or more originally simple forms, the earth would become peopled by the infinite varieties of plant and animal organisms which have in past ages inhabited, or do at present inhabit our globe. The Darwinian theory may, therefore, be defined as heredity modified and influenced by variability. It assumes that there

is an heredity quality in the egg, which, if we take the common fowl for an example, shall continue to produce similar fowls. Under conditions, of which we are ignorant, which occasion molecular changes in the cells and tissues of the developing egg, variations might arise in the first instance probably slight, but becoming intensified in successive generations, until at length the descendants would have lost the characters of the fowl and have become another species. No precise estimate has been arrived at, and, indeed, one does not see how it is possible to obtain it, of the length of years which might be required to convert a variation, capable of being transmitted, into a new and definite specific character.

The circumstances which, according to the Darwinian theory, determined the perpetuation by hereditary transmission of a variety and its assumption of a specific character depended, it was argued, on whether it possessed such properties as enabled the plant or animal in which it appeared to adapt itself more readily to its environment, *i. e.*, to the surrounding conditions. If it were to be of use, the organism in so far became better adapted to hold its own in the struggle for existence with its fellows and with the forces of nature operating on it. Through the accumulation of useful characters the specific variety was perpetuated by natural selection so long as the conditions were favorable for its existence, and it survived as being the best fitted to live. In the study of the transmission of variations which may arise in the course of development, it should not be too exclusively thought that only those variations are likely to be preserved which can be of service during the life of the individual, or in the perpetuation of the species, and possibly available for the evolution of new species. It should also be kept in mind that morphological characters can be transmitted by hereditary descent, which, though doubtless of service in some bygone ancestor, are in the new conditions of life of the species of no physiological value. Our knowledge of the structural and functional modifications to be found in the human body, in connection with abnormalities and with tendencies or predisposition to diseases of various kinds, teaches us that characters which are of no use, and indeed detrimental to the individual, may be hereditarily transmitted from parents to offspring through a succession of generations.

Since the conception of the possibility of the evolution of new species from pre-existing forms took possession of the minds of naturalists, attempts have been made to trace out the line on which it has proceeded. The first to give a systematic account of what he conceived to be the order of succession in the evolution of animals was Ernst Haeckel, of Jena, in a well-known treatise. Memoirs on special departments of the subject, too numerous to particularize, have subsequently appeared. The problem has been attacked along two different lines: the one by embryologists, of whom may be named Kowalewsky, Gegen-

baur, Dohrn, Ray Lankester, Balfour and Gaskell, who, with many others, have conducted careful and methodical inquiries into the stages of development of numerous forms belonging to the two great divisions of the animal kingdom. Invertebrates, as well as vertebrates, have been carefully compared with each other in the bearing of their development and structure on their affinities and descent, and the possible sequence in the evolution of the Vertebrata from the Invertebrata has been discussed. The other method pursued by palæontologists, of whom Huxley, Marsh, Cope, Osborn and Traquair are prominent authorities, has been the study of the extinct forms preserved in the rocks and the comparison of their structure with each other and with that of existing organisms. In the attempts to trace the line of descent the imagination has not unfrequently been called into play in constructing various conflicting hypotheses. Though from the nature of things the order of descent is, and without doubt will continue to be, ever a matter of speculation and not of demonstration, the study of the subject has been a valuable intellectual exercise and a powerful stimulant to research.

We know not as regards time when the fiat went forth, 'Let there be Life, and there was Life.' All we can say is that it must have been in the far-distant past, at a period so remote from the present that the mind fails to grasp the duration of the interval. Prior to its genesis our earth consisted of barren rock and desolate ocean. When matter became endowed with Life, with the capacity of self-maintenance and of resisting external disintegrating forces, the face of nature began to undergo a momentous change. Living organisms multiplied, the land became covered with vegetation and multitudinous varieties of plants, from the humble fungus and moss to the stately palm and oak, beautified its surface and fitted it to sustain higher kinds of living beings. Animal forms appeared, in the first instance simple in structure, to be followed by others more complex, until the mammalian type was produced. The ocean also became peopled with plant and animal organisms, from the microscopic diatom to the huge leviathan. Plants and animals acted and reacted on each other, on the atmosphere which surrounded them and on the earth on which they dwelt, the surface of which became modified in character and aspect. At last Man came into existence. His nerve-energy, in addition to regulating the processes in his economy which he possesses in common with animals, was endowed with higher powers. When translated into psychical activity it has enabled him throughout the ages to progress from the condition of a rude savage to an advanced stage of civilization; to produce works in literature, art and the moral sciences which have exerted, and must continue to exert, a lasting influence on the development of his higher Being; to make discoveries in physical science; to acquire a knowledge of the structure of the earth, of the ocean in its changing aspects, of the atmosphere and

the stellar universe, of the chemical composition and physical properties of matter in its various forms, and to analyze, comprehend and subdue the forces of nature.

By the application of these discoveries to his own purposes Man has, to a large extent, overcome time and space; he has studded the ocean with steamships, girdled the earth with the electric wire, tunneled the lofty Alps, spanned the Forth with a bridge of steel, invented machines and founded industries of all kinds for the promotion of his material welfare, elaborated systems of government fitted for the management of great communities, formulated economic principles, obtained an insight into the laws of health, the causes of infective diseases and the means of controlling and preventing them.

When we reflect that many of the most important discoveries in abstract science and in its applications have been made during the present century, and, indeed, since the British Association held its first meeting in the ancient capital of your county sixty-nine years ago, we may look forward with confidence to the future. Every advance in science provides a fresh platform from which a new start can be made. The human intellect is still in process of evolution. The power of application and of concentration of thought for the elucidation of scientific problems is by no means exhausted. In science is no hereditary aristocracy. The army of workers is recruited from all classes. The natural ambition of even the private in the ranks to maintain and increase the reputation of the branch of knowledge which he cultivates affords an ample guarantee that the march of science is ever onwards, and justifies us in proclaiming for the next century, as in the one fast ebbing to a close, that Great is Science, and it will prevail.

THE POPULATION OF THE UNITED STATES DURING THE NEXT TEN CENTURIES.

By H. S. PRITCHETT,

PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

IS it possible to predict with any degree of certainty the population of a country like the United States for a hundred years to come?

Doubtless the average intelligent person would say *à priori* that the growth of population is not a matter which can be made the subject of exact computation; that this growth is the result of many factors; and that those factors are subject to such great fluctuations that an estimate of the population a hundred years hence can be, in the nature of the case, only a rough guess.

It is true that the growth of population depends on a number of factors. It is also true that these factors vary in accordance with laws which are at present not known. Nevertheless it does not by any means follow that because the law of these variations is unknown we cannot represent the variations themselves by a mathematical equation. The problem of representing mathematically the law connecting a series of observations for which theory furnishes no physical explanation is one of the most common tasks to which the mathematician is called. And it does not in the least diminish the value of such a mathematical formula, for the purposes of prediction, that it is based upon no knowledge of the real causes of the phenomena which it connects together.

To illustrate: The black spots on the sun have been objects of the greatest interest to astronomers ever since Galileo pointed the first feeble telescope at his glowing disc. These spots, as observed from the earth, seem to pass across the disc from east to west as the sun rotates on its axis.

Among the problems with which the possessors of the first telescopes busied themselves were the observation of these spots for determining the period of the sun's rotation. The observation is a very simple one and consists merely in noting the time which elapses between successive returns of a spot to the central meridian of the disc. The earlier observers were astonished to find that the different spots gave different results for the rotation period, but it was only within the last thirty years that the researches of Carrington brought out the fact that these differences follow a regular law showing that at the solar equator the time of rotation is less than on either side of it.

The explanation which is generally accepted to account for this peculiar state of affairs is that the spots drift in the gaseous body of the

sun and that this drift is most rapid near the equator and diminishes towards the poles. But this after all only pushes the explanation a little further back, and no satisfactory theory of this drifting of the spots has ever been reached. Doubtless the phenomenon is due to a large number of causes, acting together, whose resultant effect is shown in the motion of the spots as we see them.

However that may be, and although we are still unable to give any physical explanation of the phenomenon, a formula has been devised which fits the observations fairly well and which enables the astronomer to predict the motion of the spots with an accuracy comparable to the observations themselves. This formula is a complicated one, when written in its mathematical form, and involves a trigonometric function of the latitude of the spot raised to a fractional power.

Now no one pretends that this intricate formula expresses any real law of nature. But it does express the mathematical relation which connects together the observations, and by means of it the motions of the spots at different latitudes on the sun may be predicted with all desirable accuracy.

The problem of deriving an equation which shall represent the growth of the population of the United States during the past one hundred and ten years and which may be used to predict its growth through future decades, is exactly such a case as that of the sun's spots just mentioned. The observations in this case consist of eleven determinations of the population as given in the census returns from 1790 to 1890.

In studying these observations of population, taken at regular intervals of ten years, it occurred to me some years ago to examine them with some care in order to discover whether they were related to each other in any orderly way, and if so whether they could be represented by an equation of reasonable simplicity. It is evident that if an equation can be found which will fit the growth of population during the hundred years which intervened between 1790 and 1890 it would form the most probable basis for predicting the population of the future.

Somewhat to my surprise I discovered a comparatively simple equation which represented the census enumerations very closely and which, notwithstanding the fluctuations in the various factors which affect the growth of population, followed the general course of this growth with remarkable fidelity, as will be seen by the following table, which shows the population as given by the Census Bureau and as determined by the empirical formula. The discrepancies between the observed population and that computed from the formula are also given for the sake of an easy comparison. In each case the population is given to the nearest thousand, a figure far within the limit of error of the census count.

Year.	Observed Population.	Computed Population.	Discrepancy.
1790.....	3,929,000	4,012,000	83,000
1800.....	5,308,000	5,267,000	41,000
1810.....	7,240,000	7,059,000	181,000
1820.....	9,634,000	9,569,000	65,000
1830.....	12,866,000	12,985,000	119,000
1840.....	17,069,000	17,484,000	415,000
1850.....	23,192,000	23,250,000	58,000
1860.....	31,443,000	30,468,000	975,000
1870.....	38,558,000	39,312,000	754,000
1880.....	50,156,000	49,975,000	181,000
1890.....	62,622,000	62,634,000	12,000

The smallness of the discrepancies and the consequent close agreement of the formula with the observations show that the growth of the population has been a regular and orderly one. There are, however, two residuals which have abnormally large values. The census of 1860 shows a population of 975,000 larger than the computed value, while that of 1870 falls 754,000 below that of the computed value.

The explanation of these discrepancies is not far to seek. The devastating effect of the war would show itself in the census of 1870 and succeeding years. The effect would be to give 1870 a smaller observed value than would be expected. This is precisely what we find to be the case, the census of that year falling 754,000 short of the computed value. An abnormally small value in 1870 would, of course, have its effect on the population of succeeding decades and would also give an apparent difference of opposite sign to the observed population in 1860.

There is, however, good reason to believe that the population in 1870 as determined by the census was much smaller than the actual population at that time. Mr. Robert Porter, in Census Bulletin No. 12, October 30, 1890, makes the statement that the census of 1870 was grossly deficient in the Southern States and that a correct and honest enumeration would have shown at that time a much larger population than that actually returned by the Census Bureau. There are, of course, no means of ascertaining exactly the extent of these omissions, but there is no question that the population as computed by the formula for 1870 is far nearer the truth than the value given by the census for that year.

However this may be, it is evident that the formula represents the general law of growth which held between 1790 and 1890 with an accuracy almost comparable with that of the census determinations themselves. The question of immediate interest, however, is not whether the growth of population during the last century can be represented by a mathematical formula, but it is that which stands at the beginning

of this paper, viz., can the population of the United States an hundred years hence be predicted within reasonable limits of error?

During the past century the factors which govern the growth of population have fluctuated enormously; there have been wars and epidemics; there have been decades in which large numbers of emigrants landed upon our shores and there have been other decades in which emigrants were few; there have been years of plenty and years of want; booms and panics, good times and hard times have had their share in the century which has passed. Yet notwithstanding all these varying conditions, the growth of the population has been a regular and orderly one, so much so that it can be represented by a comparatively simple mathematical equation. Can this equation be trusted to predict the population in the decades which are to come?

How closely the formula will represent the population of the future will depend, of course, upon the continuance of the same general conditions which have held in the past. This does not mean that exactly the same factors are to operate, but that on the whole the change of one factor will be balanced by a change in another, so that in the main the character of the growth manifested during the past century will be continued. A decided change in the birth-rate or a widespread famine would bring out large discrepancies. But on the whole it may be expected that the experience of the last hundred years involves so many varying conditions that the general law of growth which satisfies that period will continue to approximate the development of the population for a considerable time to come.

This does not mean that any particular census enumeration of the future will be represented closely, but simply that in the main the computed values will follow the general growth of the population. The law of probabilities will lead one to expect at times considerable variations. The preliminary announcements from the Census Office, as given in the daily papers, indicate a result for 1900 of about 75,700,000 people, a value considerably below the computed one. This would mean that at this epoch the formula was not representing the actual growth, but does not at all indicate that it will cease to represent the general growth of the succeeding centuries. In any event this method furnishes the most trustworthy estimate which can be made for the future, since it gives the result which is mathematically most probable and which is based on all the data of the past. Carrying forward, therefore, the computation we obtain the following values for the most probable population of the future:

Year.	Computed Population.
1900	77,472,000
1910	94,673,000

1920	114,416,000
1930	136,887,000
1940	162,268,000
1950	190,740,000
1960	222,067,000
1970	257,688,000
1980	296,814,000
1990	339,193,000
2000	385,860,000
2100	1,112,867,000
2500	11,856,302,000
2900	40,852,273,000

The law governing the increase of population, as generally stated, is, that when not disturbed by extraneous causes such as emigration, wars and famines, the increase of population goes on at a constantly diminishing rate. By this is meant that the percentage of increase from decade to decade diminishes. It will be noticed that the figures just given involve such a decrease in the percentage of growth. A simple differentiation of the formula gives as the percentage of increase of the population per decade 32 per cent. in 1790, 24 per cent. in 1880, 13 per cent. in 1990, while in one thousand years it will have sunk to a little less than three per cent. But according to the formula this percentage of increase will become zero, or the population become stationary, only after the lapse of an indefinite period.

The figures just quoted are, to say the least, suggestive. Forming, as they do, the most probable estimate we can make for the population of the future, they suggest possibilities of the highest social and economic interest. Within fifty years the population of the United States (exclusive of Alaska, of Indians on reservations and of the inhabitants of the recently acquired islands) will approximate 190 millions, and by the year 2000 this number will have swelled to 385 millions of people; while should the same law of growth continue for a thousand years the number will reach the enormous total of 41 billions.

How great a change in the conditions of living this growth of population would imply is, perhaps, impossible for us to realize. Great Britain, at present one of the most densely populated countries of the globe, contains about 300 inhabitants to the square mile. Should the present law of growth continue until 2900 the United States would contain over 11,000 persons to each square mile of surface.

With the growth of population our civilization is becoming more and more complex and the drafts upon the stored energy of the earth more enormous. As a consequence of all this, it would seem that life in the future must be subject to a constantly increasing stress, which will bring to the attention of individuals and of nations economic questions which at our time seem very remote.

THE DISTRIBUTION OF TAXES.*

By EDWARD ATKINSON.

IN nearly all the discussions upon the subject of taxation which have come to my notice, it is assumed that certain specific taxes fall upon and are borne wholly by one class; other taxes fall upon and are borne by a second class; and so on throughout the list. For instance, in the discussion regarding a protective tariff it is held by the advocates of protection that in some cases the imposition of a duty reduces the price of the imported article in the foreign country from which it comes. It is, therefore, held that such a tax may be put upon the foreign producer and is not paid by the domestic consumer. It is held that other duties on other imported articles are added to the cost of importation, then as far as possible added to the price, and are thus distributed in ratio to their consumption. Unless such should be the result of imposing duties on foreign imports, namely, that they may either be borne in the first instance by the foreign producer, or may be distributed on the domestic consumer, there could be no continuous import of any foreign product. Even if it could be proved that some duties are paid by foreign producers, such reduction in price would limit his power of purchase of our domestic goods taken in exchange.

It is also held that excise taxes on liquors and tobacco must be charged to the cost of production, must be recovered from the sales and are, therefore, distributed in ratio to consumption. It is held by the advocates of what is called the single tax that a tax on rent or rental values will be paid out of the rents accruing to the landlord, and that this tax cannot be distributed by him, but that it simply diminishes his income. It is held that a tax on incomes is paid by those who enjoy the income, diminishing their resources. Finally, it is held that a tax on inheritances and successions is taken out of the property and that it cannot be distributed.

All these theories, presented in different forms, are and have been subjects of discussion. They have been debated ever since the subject of taxation became in any measure a matter of scientific inquiry. The conclusions reached by different persons or schools of political economy so-called, are as much at variance now as they have ever been.

I have reached the conclusion that all taxes, wherever placed, however imposed, and through whatever agency collected by the govern-

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ment, either national, State, city or town, are distributed, falling ultimately upon all consumers in proportion to the quantity and value of the product of the country consumed by each person.

What is the cost of each person to the community? Is it not what each person consumes of the materials needed for shelter, food and clothing? What does any one get in or out of life, in a material sense, be he rich or poor, except what we call board and clothing? Incomes in money are distributed. When paid for service that money becomes the means by which the person who has performed the service procures shelter, food and clothing.

If these points are well taken, then it seems to me that the only problem is how much time will elapse before the tax will fall upon the consumers of all products in ratio to consumption; an incidental question being the relative cost of collecting the taxes in one way or another.

I have been led to this conclusion that all taxes are slowly but surely diffused throughout the community—some directly, others indirectly—by reasoning upon the subject without measuring the tax in terms of money—money being only the medium by which the real tax is measured and brought to the use of the government. Does not the same distinction apply to taxes that applies to wages? We are accustomed to speak of money wages and real wages, meaning by real wages the things that money will buy. May we not in the same way speak of money taxes and real taxes, meaning by real taxes the material substances withdrawn from the community for the support of the employees of the government? Does not the real tax consist of the material products needed by and consumed for the subsistence of the officers of the government and of all persons who are in the government service?

The annual product is substantially the source of these material substances. A small part of one year's product is carried over to start the next year's product, a small part of that year being carried forward on which to begin work in the next. Production is a continuous process, but it is governed practically by each series of four seasons. Now, if the real tax is that part of the annual product withdrawn from general consumption to serve the special consumption of the persons who are in the government service, or are pensioned by the government, then by so much as the annual product measured in quantities is lessened in order to meet that demand, will the quantity remaining for distribution among those who directly take part in productive work be diminished.

In the expenditure of the money derived from taxation the government secures materials for constructing buildings, for their furnishings and fittings; for constructing coast defenses; for building naval vessels;

for supplying food, shelter and clothing to all government employees and dependents. With respect to armaments, military and naval, all the materials for the construction of vessels, forts, arms and equipments must be taken from the common stock which is derived from the annual product. The rations and clothing of soldiers, sailors and pensioners must be provided in the same way.

It follows that by so much as these government forces, military and naval, are increased will the proportion of products withdrawn from productive consumption be augmented. If these military expenditures go beyond the absolute requirements for defense, leading to the establishment of a large standing army and a great navy, every one must bear his proportion of that burden, because what is taken from the common stock for these destructive purposes is nothing but the material for shelter, food and clothing which would otherwise be constructively or productively expended. By so much as the burden of militarism is augmented must poverty be increased.

I do not mean to give the idea that many of the functions of government are not necessary and are not productive in a true sense. The functions of the civil government are as necessary to the conduct of productive industry and the government employees in this service are as much needed as are the services of any other body of men who are not directly occupied in the mechanical and manual work of production or distribution. The officials of a just government supply mental energy, the fourth and paramount factor in all production. Hence, the constructive work of governments must be carefully kept distinct from the destructive work of militarism. All that is taken from the annual product either to pay debt incurred in war, or the interest thereon, or for the support of armies or navies, is destructive and not constructive in its immediate application to any given year. By so much as food, shelter and clothing are taken from the annual product for military or destructive purposes, by so much is the quantity lessened which would otherwise be consumed for reproductive purposes. Whether or not such destructive consumption may be justified or otherwise is not a question at issue in this discussion; I merely present the facts and intend to show what militarism costs.

We now come to the relative burden of taxation. If by way of taxation so large a part of the annual product is taken for destructive purposes as to leave less than a sufficient supply for necessity and comfort, then the time has come for revision and removal of taxes lest degeneration should ensue. The case of Italy may be cited. It is stated by Italian economists that from twenty-five to thirty per cent. of the annual product of Italy is expended in support of the government, mainly for the destructive purposes of militarism; the consequences being that great bodies of people cannot get enough to eat—there is not enough to

go round. Of course, the richer classes can buy what they need, therefore the ultimate and destructive burden of militarism falls upon the poor and the incapable. I think it cannot fail to be admitted that by so much as products are taken by the government for consumption outside the civil service, mainly for military purposes, in the form of food, fuel, metal, timber and the like, by so much is there less of these materials to be expended for subsistence and for the construction of dwelling houses, factories, workshops and the mechanism of productive industry. If such productive consumption is retarded by an excessive tax on inheritances or on incomes, then the accumulation of capital is retarded, and by so much must the rate of interest or profit be higher than it would otherwise have been. The distribution may be very remote, but it is very certain, unless one is prepared to admit the absurd cry of over-production and to defend a waste of substance by way of taxation in order to get rid of it.

All these material substances which are applied in the end to the supply of shelter, food and clothing are the joint product of land, labor, capital and mental energy. They are derived directly or indirectly from the field, the forest, the mine or the sea. There can be no large production conducted exclusively by labor; tools are necessary. Tools are capital, whether used by hand or worked by power. On the other hand, there can be no production exclusively derived from capital; tools and mechanism without human power or direction are inert. Land is the basis of all production, yet raw land is practically inert. Land is but a tool or instrument of production and has been so ever since the nomadic life gave place to civilized life. Again, there can be no great product, of either land, labor or capital, of either manual or mechanical work, without the directing or coordinating power of mental energy, bringing all these material forces to a constantly augmenting product in ratio to the number of persons occupied in their conduct.

If, then, the entire product of land, labor, capital and mental energy in a given period, consisting of four seasons or one year, is represented by the symbol A, that part of the product which is converted to the uses of government by taxation may be represented by the symbol B; then A minus B equals X, the unknown quantity. If X, the unknown quantity, is the share of the annual product of material substances used for shelter, food and clothing, then the whole burden of taxation, wherever imposed and however collected, with all the expenses of collection, be they greater or less, must fall in the end upon all consumers in proportion to their consumption by diminishing the quantity or value of X.

It follows that if the demand of governments takes so large a portion of the product that what is left is insufficient to meet the necessity and comfort of those who are not in the government service, then, as

a matter of course, the people with the larger incomes will buy all they need with the necessary consequence that the final burden falls on those least able to bear it.

All systems of taxation have adjusted themselves more or less logically to these conditions.

It has been found in practice among all civilized nations that any large amount of taxation must be derived from a few articles of very general use; as, for instance, our national taxes on liquors and tobacco have for twenty years preceding the Spanish war annually averaged two dollars and a half ($2.50) per head, that rate sufficing to meet the normal expenses of the government during the same period. That is to say, taxes on liquors and tobacco, domestic and foreign, have annually yielded a revenue in money sufficient for twenty years prior to the Spanish war for the support of the civil service, and the army and the navy before these forces were augmented beyond the requirement of national defense. The taxes necessary to meet pensions and interest have been derived from other sources. In other words, under normal conditions, had we paid the national debt, as we might have many years ago without feeling the burden in any considerable measure, and had our pensions been limited to true cases, the people of this country would only have been called upon to forego a part of their consumption of liquors and tobacco in order to support the national government. At the present time, under the augmented taxes on liquors and tobacco, the revenue from these sources is between three dollars and a half ($3.50) and four dollars ($4) per head.

Great Britain, France and Germany derive a large part of their revenues from the same sources, namely, from these and other articles which are consumed in largest measure by the millions rather than by the millionaires. These taxes are collected at the least cost for collection and they meet a true canon of taxation, taking from consumers a part of a product which consumers can spare without impairing their productive energy.

Again, we may find the almost necessary resort of the British Government in India to a salt tax, because it is only through the tax on salt that the masses of the people can be reached, the next great resource of East Indian revenue being what is practically a single tax on land, assessed directly without regard to the relative product year by year. These taxes on salt and land admittedly reduce a large part of the population of India to such condition of extreme poverty that when a bad year comes famine devastates the land. The hoards of wealth in India are enormous, but they cannot be reached. The problem of taxation in India is not a question of will but of power to collect.

The octroi tax imposed upon the traffic of the city with the country, now in force in France, Italy and some other countries, rendered neces-

sary by the magnitude of the burden of taxation, is one of the most obnoxious of all methods of distributing military burdens.

Finally, the relative burden of taxation cannot be estimated nation by nation by mere computation in symbols or money. The taxation by the measure of money of the United States for national purposes before the war with Spain was five dollars per head, tending to lessen. In Great Britain and Germany taxes for the same purposes were about ten dollars per head; in France about fifteen dollars. But this is no measure of the true burden of taxation. The annual product of this country measured by quantities is vastly greater than that of any European country. It may be approximately estimated twenty-five per cent. greater than that of the people of Great Britain and Ireland, thirty to forty per cent. greater than that of France, double that of Germany, and much more than double that of Italy. Hence, the real taxation of these European countries under their military establishments is vastly more than the mere symbols in money make it appear.

It follows that if all taxes in money stand for that part of the annual product required by Government, and that by so much as the product is diminished will the share falling to labor and capital be lessened, the only way to prevent taxation becoming a cause of pauperism or poverty is to limit the taxes to the necessary conduct of civil government and to national defense, avoiding aggression and forbidding armaments for any purpose except defense.

MUNICIPAL GOVERNMENT NOW AND A HUNDRED YEARS AGO.

By CLINTON ROGERS WOODRUFF.

A HUNDRED years has wrought marvelous changes. The maps of Asia, Europe and America, of the world, have been changed. The United States of America has fought four wars and demonstrated her prowess on sea and land, at home and abroad. The country has grown from a handful of States strung along the Atlantic seaboard to a great and powerful nation, extending from sea to sea, conquering and subduing in its growth a mighty continent—the mightiest in its latent possibilities on the face of the globe. Commerce and industry and transportation have grown with equal, if not greater, strides, and the time is not far distant, if it has not already arrived, when America will dominate the world along these lines.

Our development thus far has been extensive; during the coming century it will be intensive. A few more decades and the partition of the globe among the world powers will be practically completed; then we shall be compelled to cultivate with closer attention and greater zeal and more care our resources. Intensive culture will succeed extensive cultivation. The great mechanical inventions of the nineteenth century have directly aided the extensive movement—the steam railway, the steamship, the telegraph, the cable, the telephone; the inventions of the next century will as directly aid the intensive movement—they will be designed to make the most of what we have.

Our political problems have also been problems of extension. First, the government and division of the Northwest Territory; then the acquisition and organization of the Louisiana Territory; of Florida; of Texas; of the Southwest Territory; of the Oregon country and California; then the settlement of the great question as to whether the country should be divided, and its reconstruction on the principle that it was one and indivisible; and latterly, Hawaii, Porto Rico and the Philippines. The political problems of the twentieth century will deal with questions of internal development and improvement. The government control, ownership and operation of the great natural monopolies, civil service and constitutional reforms will occupy the time and attention of our statesmen.

Our municipal growth and development during the past hundred years has likewise been along the lines of extension. Our cities have grown in numbers, population and territory. The figures are so

familiar and have been so frequently exploited as to obviate the necessity of repetition. The papers are and have been full of Metropolitan Boston, Greater New York, Greater Chicago, Greater Jersey City, Greater Newark—Philadelphia has been Greater Philadelphia since 1854, when the Consolidation Act made the City and County of Philadelphia co-terminous. Indeed, municipal expansion seems to be quite as much the vogue, quite as much the logical sequence of events, quite as much the outgrowth of an inherent Anglo-Saxon instinct, as national expansion.

This development has not been confined to population and territory, but has extended to municipal functions as well. In 1800, if an American city provided for paving the streets and cleansing them of the grosser and fouler impurities; for a few night watchmen and a handful of constables; for cleaning and repairing the sewers and docks; and for lighting the streets with miserable oil-lamps, its 'Fathers' thought that they were performing their whole duty to the inhabitants.

According to a recent authority (Parsons, in 'Municipal Monopolies', 1898), the various courts of this country have decided that the following are now proper public purposes and proper objects of municipal control and ownership: "Roads, bridges, sidewalks, sewers, ferries, markets, scales, wharves, canals, parks, baths, schools, libraries, museums, hospitals, lodging houses, poorhouses, jails, cemeteries, prevention of fire, supply of water, gas, electricity, heat, power, transportation, telegraph and telephone service, clocks, skating-rinks, musical entertainments, exhibitions of fireworks, tobacco warehouses, employment offices."

We have made but a beginning, however, according to the testimony of another recent writer (Dr. Milo R. Maltbie, in 'Municipal Functions', page 784), who says:

"Whither is all this tending? Whatever a few years since may have been the answer suggested by conservatism, there is to-day but one, and that so obvious as scarcely to be questioned. The extension of municipal functions in the direction in which the city is to act as the servant of the individual has barely begun; and its scope, certain to be indefinitely increased in a comparatively near future, is to be measured only by the resources of developing invention and enterprise, so rapidly developing of late that their early realization will be such as to be unthinkable now. The individual will have cheap facilities for transport and communication. The product of his labor will be multiplied in advantage to him by the coöperation for which cities alone give a chance. He will not be left to the hard paths which chance may afford for education of his mind and his senses, but have this facilitated by every device of civilization. It is, therefore, natural, inevitable, indeed, that there should be provided for him first, water, the prime essential of life and health; next, the first of its conveniences —artificial light; later, those universal incidents of its growth—high-

way facilities (including power supply, as well as a clear path); and, finally, education and recreation."

The tremendous advances of municipal government during the present century can be best and most graphically demonstrated by a comparison of the respective budgets of a single city for the years 1800 and 1899. Let us take Philadelphia as an example. According to Allinson & Penrose, in their work on the 'Government of Philadelphia' (pages 115-116), the budget for the former year as contained in the ordinance of February 20, 1800, was as follows

To meet the deficiency of the tax of 1799	$1,315.44
Interest on water loan	4,200.00
Interest on debts due the banks	1,200.00
Purchase of paving stones and repair of old pavements	1,600.00
Repairs to unpaved streets, &c., paving intersections	2,400.00
For cleansing city	11,250.00
Cleansing and repairing sewers and docks	1,850.00
Lighting and watching the city	18,000.00
Repairs of pumps and wells	2,500.00
Regulating streets	400.00
Center Square improvements	1,650.00
Salaries of City Commissioners and clerk	2,800.00
Expenses of City Commissioners and clerk	100.00
Salaries to Mayor, Recorder, High Constable, clerks and messengers of Councils	3,000.00
Pay of constables for patrolling streets on the Sabbath day	156.00
Incidental expenses of Councils	600.00
Residuary fund for preventing and removing nuisances	4,478.56
Reimbursement from tax fund to corporate fund, 1799	165.92
Other advances by citizens	360.00
Salaries of clerks of markets	1,200.00
Menial service in markets	560.00
Repairs, &c	700.00
Meeting contract engagements for maintenance of two steam engines	8,000.00
Total	$68,485.92

The expenditures for 1899 (exclusive of the amounts appropriated for the maintenance of the county offices) were:

Mayor's Office	$587,770.00
Bureau of Charities	500,308.00
Bureau of Correction	203,295.00
Department of Public Safety—	
Director's Office	18,721.25
Bureau of Health	251,838.08
Bureau of Building Inspectors	46,636.75
Bureau of City Property	777,751.73
Electrical Bureau	1,118,017.78

Bureau of Boiler Inspection	$15,650.00
Bureau of Fire	979,501.20
Bureau of Police	2,732,483.31
Department of Public Works—	
Director's Office	27,963.49
Bureau of City Ice Boats	22,900.00
Bureau of Highways	3,343,?89.92
Bureau of Street Cleaning	903,033.00
Bureau of Lighting	287,690.00
Bureau of Surveys	5,014,008.36
Bureau of Water	2,519,425.00
Board of Port Wardens	20,208.40
Board of Revision	147,255.00
Department of City Commissioners	921,054.50
Department of City Comptroller	60,249.52
Department of Law	155,490.00
Department of City Treasurer	4,416,867.43
Department of Clerks of Councils	140,237.95
Fairmount Park Commission	596,104.69
Reed Street Prison	87,172.25
Holmesburg Prison	84,307.43
Public Building Commission	1,011,194.43
Department of Receiver of Taxes	163,205.93
Department of Sinking Fund Commissioners	1,450.00
Department of Education	5,068,253.94
Nautical School of Pennsylvania	20,000.00
Department of Gas	5,921.54
Total	$30,958,382.88

In the year 1897, $3,399,672.43 were appropriated to the Bureau of Gas; but in that year the city (through its Councils and the Mayor) leased the gas works to a private corporation, so that now the city has to maintain a department for inspection only.

The population in 1800 was 70,287, the budget $68,485.92; the per capita expense, therefore, 97 cents. The population in 1899 was approximately 1,115,000; the budget $30,958,382.88; the per capita expense, $27.76. This great increase is due mainly to the fact that the city does more for the citizen than it did one hundred years ago, and is constantly doing more, and partly to the fact that a much larger territory is covered.

In 1897 Philadelphia had 433 public schools, with 3,465 teachers; in 1800 there were none. In 1899 there were 2,191 policemen, commanded by 6 captains, 34 lieutenants, 196 sergeants, with 23 patrol wagons, and requiring an appropriation of $2,732,483.31; in 1800 there was a handful of constables, paid out of an appropriation of $18,000 'for lighting and watching the city', and another of $156 for 'patrolling streets on the Sabbath day'. In 1899 there were 46 fire engines, 32 combination wagons and chemical engines, 15 chemical engines, 13

hooks and ladders, 15 hose carts, manned by 736 firemen, including 1 chief, 8 assistant chiefs and 57 foremen, and the appropriation for the whole bureau amounted to $979,501.20; in 1800 the city was dependent on volunteer fire companies of limited usefulness. In 1899 the sum of $1,118,017.78 was appropriated for electric lighting and $279,930.00 for gasoline lighting, and 19,417 gas lamps were lighted by the gas company; in 1800, $18,000 sufficed for 'watching and lighting' the city.

It is when we come to consider the activities of a bureau like the Electrical Bureau of Philadelphia, however, that we find the most amazing developments. I was about to say changes and advances, but there was nothing corresponding to it a century ago. Chief Walker, of the Electrical Bureau, in a recent report to the Director of Public Safety, summed up the situation in these words:

"Among the many bureaus in the department over which you so ably exercise the directorship, there is none, perhaps, whose duties are so varied and which embraces a system so diversified in its branches and which is required to be so persistently active, as the Electrical Bureau. Correspondents from other cities frequently ask what duties are concentrated in, and what knowledge is necessary to an effectual supervision of the affairs of the Electrical Bureau. An enumeration of the various duties assigned includes, among others, the *Police Telegraph*, the artery through which the orders and wishes of the officials of the executive branches of the municipality are transmitted, and the medium of communication for all municipal affairs requiring immediate attention; the *Fire Signal System*, over whose wires the signals are sent from localities threatened with the dangers of a conflagration; the *Fire Alarm System*, by means of which the signals received over the Fire Signal System are transmitted to those skilled and trained in the handling of the magnificent apparatus provided for the suppression of fire; the *Fire Signal and Telephone System*, a very efficient auxiliary to the Bureau of Fire, by means of which verbal communication is possible between the Chief of the Bureau and his aids, and which at the same time serves as an additional means of transmitting alarms to the Bureau of Fire; the *Police Signal and Telephone System*, by means of which the officials of the Bureau of Police are in almost constant touch with the patrolmen while on their respective beats, and which has proved its value many times over; the *Trunk Line*, between the local and long distance telephone exchanges entering the City Hall, which are of necessity under control of this office, centering at a switchboard in the operating room, where the necessary connections are made by employees of this bureau; the *Telephone Service* between the police stations and their sub-stations, by means of which the officers in charge of the district are in constant communication with their subordinates. The armories of the National Guards and the officers of the various hospitals are in direct communication with and the services connecting them are supervised and maintained by this bureau.

What might be termed the general municipal telephone system, embracing the system of inter-communication in City Hall and con-

nections with all officers that are not yet installed therein, and all other municipal telephone connections are centered in and controlled by this bureau.

All electric lights authorized by Councils are located and their erection supervised by this bureau. Tests of electric lights so authorized and erected are made by us, and if not up to contract standard, deductions are made from the contracting companies' bills.

By ordinance of Councils, we are required to locate each and every pole for telegraph, telephone, electric light, trolley, or whatever electrical purpose, to issue a license for the same, for which, with the exception of the trolley poles, a fee payable at the City Treasury is charged. No poles or wires can be erected within the city limits without a permit issued from this bureau, describing its location, if a pole, and its direction, if a wire.

All conduits for municipal electrical purposes authorized by Councils are laid by this bureau, as are cables necessary for the connection of the various municipal electrical services. All scientific electrical tests of cables are also made by this bureau.

As a member of the Board of Highway Supervisors, the Chief of the Bureau is required to pass upon the location and position of all electrical constructions under and over the highways, and to approve of the materials used and the methods employed in its installation and maintenance. All minor details of electrical construction necessary to the needs of a municipality are formulated and carried forward to successful completion."

Surely a wonderful work; unheard of, yes—I venture to say, unthought of, in the mind of the most imaginative thinker a century ago!

Search we never so carefully, we can find nothing in the budget or reports of 1800, or for those of many years later, which in anywise approaches or approximates this work—for the simplest of reasons—that electricity had not as yet been harnessed to bring the distant near and to eliminate space. Fancy the constable of 1800 communicating every hour with his headquarters without leaving his beat; or having an alarm of fire sounded simultaneously in every section of the city, no matter how remote! Imagine the look of incredulity which would descend upon a citizen who was told that he could be placed in communication with a city official in less than a minute and without leaving his office!

Our municipalities have grown and have developed along extensive lines to an unexpected degree, and the same factors that have been at work in our national development in the same direction have been at work in our municipal development, and the same observation will apply—the next century's development in our cities will be along intensive lines. Already, we see the tide setting in this direction. Take, for instance, the growing demand for charter reform. During the expansive period of a city, everything is sacrificed to size and numbers; the form and methods of government are considered as of secondary

importance. When this period is passed there comes a time when the necessity for a conscious adjustment of the form of government to the new conditions and environment becomes paramount; then follows the demand for a new charter; and charter amendments and charter conventions become the order of the day.

Recognizing that we had reached this stage of our development, the National Municipal League, at its Louisville meeting, held in 1897, adopted the following resolution:

"*Resolved*, That the Executive Committee appoint a committee of ten to report on the feasibility of a municipal program, which will embody the essential principles that must underlie successful municipal government, and which shall also set forth a working plan or system, consistent with American industrial and political conditions, for putting such principles into practical operation; and such committee, if it finds such municipal program to be feasible, is instructed to report the same, with the reasons therefor, to the League for consideration."

The committee thus authorized presented its preliminary report at the Indianapolis Conference for Good City Government in 1898, and its final report to the Columbus Conference in 1899. While it is fully aware that its "recommendations do not constitute the last word on the subject, nevertheless the fact that a body of men of widely divergent training, of strong personal convictions, and who approached the matter in hand from essentially different points of view, could and did come to unanimous agreement that a 'Municipal Program' was feasible and practicable, and by fair and full comparison of opinion were able to embody the result of their agreement in definite propositions, is a hopeful augury." This committee realized that "good government is not to be achieved at a stroke, nor do we exaggerate the importance of the form of governmental organization as a factor contributory to this end. Civic advance in general, and municipal efficiency in particular, are the result of a combination of forces, of which higher standards of public opinion and lofty civic ideals are the most important."

Another sign of the times is the formation of organizations like the League of American Municipalities, the State Leagues of Municipalities, the American Society of Municipal Improvements, the National Association of Municipal Electricians, the various societies of fire and police and other municipal officials. These indicate that those who are actually and directly responsible for the administration of municipal government are awakening to their responsibilities, to the need of conference to advance the interests committed to their care. The time was, and that not very far distant, when the principal rivalry between cities was confined to population figures and extent of territory. Now a healthful and auspicious competition based on efficiency is

springing up, and such societies and organizations as those to which I have referred foster and encourage this tendency.

We have only to examine the program of conventions such as that held under the auspices of these societies to be convinced of the earnestness and sincerity of purpose of their sponsors. Hard practical questions of municipal administration are to the front. The men come together to exchange views and ideas as to how to conduct certain lines of municipal business—not to listen to useless, though perhaps graceful, oratory and senseless bombast and adulation. Some may decry conventions; but certainly not such as serve so useful a purpose as those conducted under the associations already mentioned. They are a sign of the times—a most auspicious sign of the times. Do you read anywhere a century ago that the mayors or aldermen or constables of that time came together to confer about municipal affairs? We may not hear of them a century hence, because they may have performed their function and gone the way of other good and useful means to an end; but at this time they indicate the change taking place in our development; the change in emphasis.

I do not propose to indulge in prophecy. I am not so gifted with foresight as to be able to peer into the future and read its message. I can only express a personal opinion as to the possible result of present tendencies, based upon a study of present and past developments. I have already indicated what I believe will be the greatest change, that from extensive to intensive growth and development, and with this will come a great amelioration of many of the present-day evils.

The instinct for territorial expansion gratified, the various world powers and their possessions will tend more and more to assume a condition of permanent equilibrium. Great armaments and vast armies will become less and less necessary. Economic causes plus political necessity plus moral growth will gradually result in the substitution of mediation, arbitration and conciliation for warfare and bloodshed. Already the beginning of this substitution is at hand. We have the Argentine-Italian treaty providing for the submission of practically every difficulty to arbitration; similar treaties under consideration; and the Delagoa Bay arbitration has just been completed.

The accomplishment of these ends will result in a transfer of political energy and ability. Constructive statesmanship, liberated from considerations of expansion and colonization, will be free to devote itself to the great questions of internal improvement. Our municipalities will correspondingly benefit and will have at their command that genius and that ability which seem to be a chief characteristic of the Anglo-Saxon race, but which hitherto have been absorbed by national and international activities.

Civil service reform, which lies at the very foundation of efficient

government, will become an accomplished fact from the very necessity of things. A century ago there was no need for it, because the number of offices was so small and the interests involved practically so limited. A century hence the number of offices will be so great and the interests so vast, that it will be an impossibility to administer them upon any other basis. Public opinion on fundamental political questions changes slowly; but already we see evidences that there is a growing resentment to the use of public office to pay political debts. The business instinct of the people is slowly but surely asserting itself to the same end. There is a growing appreciation of the fact that an electrical bureau or an engineering bureau or a survey bureau cannot be successfully and efficiently conducted on a spoils basis.

No one doubts or denies that municipal reform is to-day a great and pressing problem, constantly attracting more and more attention and bidding fair, in the course of advancing years, to become a dominating one. When we have accomplished what we are now striving for—civil service reform, the elimination of State and national politics from the consideration of municipal affairs, the conduct of the latter upon enlightened principles, the extension of educational facilities, municipal reform will choose other objects for its end; otherwise, America would not be true to its Anglo-Saxon heritage. One reform achieved, then the Anglo-Saxon presses forward to another. He would not be true to his instinct if he did not. We may not, and I for one believe we shall not, be discussing civil service reform, ballot reform, municipal ownership, a century hence; nor will a National Municipal League perhaps be needed to preach the doctrine of an aroused civic consciousness. These will be accomplished facts, if we may judge of the future by the past and present—but none of these things will come to pass unless every one who now feels the obligations of his political duties is true to the best that is within him. The secret of the greatness of America and England in the civilization of the world is that there has always been a sufficient number of men to respond when a Nelson said, 'England expects every man to do his duty.' Whenever that day passes, then the greatness of the Anglo-Saxon race shall have departed.

CHINA.*

By WILLIAM BARCLAY PARSONS.

EVER since the days when Marco Polo brought back to Europe the seeming fairy tales of the wonderland of the Far East, the country to which we have applied the name of China has been a field more and more attractive for commercial conquest.

At the close of the nineteenth century, when the ever-rising tide of industrial development has succeeded in sweeping over Europe, America, the better portion of Africa, of Western Asia and India, it is the Chinese Wall alone that resists its waves. The movement, however, is irresistible, and not even the exclusiveness of the Chinese and their extreme disinclination to change their ways will be a sufficient protection against it; the recent so-called 'Boxer' outbreak will probably prove to be the death knell to Chinese resistance. Whatever may be the outcome of this outbreak, in so far as it affects the government, or the political integrity of the country, it can be predicated in safety that the commercial and industrial life of China will be revolutionized, and the beginning of the twentieth century will be found to mark the dawning of a new era.

The present moment when we are about to pass from the old into the new state of things is a fitting time to survey the field of industrial enterprise by examining into what has been done and to ascertain the sort of foundation that has been prepared, on which the Chinese people, aided at first by foreigners, will eventually of themselves erect their own industrial structure.

In the consideration of this very interesting land there seems to be a surprise at every turn, and one of the most peculiar is that we are met at the outset by the curious circumstance that it is a country without a name. The Chinese themselves have no fixed designation for their country, using as a general thing either the 'Middle Kingdom,' or the 'Celestial Kingdom,' or the 'Great Pure Kingdom.' The interpretation of the first is that the people consider China to be the center of the world, all the other countries surrounding and being tributary to it; although the term probably originated when what is now the Province of Ho-nan was the central kingdom of several other kingdoms which went to make up a united country. The name 'Celestial Kingdom' is a piece of self-flattery, the Chinese Emperor being called in like manner

*This article will form part of a book entitled "An American Engineer in China," to be published shortly by Messrs. McClure, Phillips & Co.

the 'Son of Heaven;' while the last name, that of the 'Great Pure Kingdom,' follows the designation of the present ruling house, which styles itself the 'Pure Dynasty,' in contradistinction to the preceeding dynasty which it overthrew, and which was called the Ming or 'Bright Dynasty.' The foreigner's appellation of China is of uncertain origin, but it is supposed to mean the land of Chin or Tsin, a family that ruled about 250 B. C., and even this name is used indiscriminately as covering two areas very different in size. When we use the word China it may mean the Chinese Empire proper, the empire of the eighteen provinces; or it may mean the eighteen provinces and the dependencies of Manchuria, Mongolia and Tibet, whose bond of attachment to the empire, in strength, is in the above order. The eighteen provinces comprise in area about 1,500,000 square miles, or an area about equal to that portion of the United States lying east of Colorado. The shape of the empire proper is substantially rectangular, extending from the latitude of 42° north, which is about that of New York, to 18° north, or the latitude of Vera Cruz. When the dependencies are included under the title of China the northern boundary is carried to the forty-eighth parallel, or say the latitude of New Foundland, and the whole has an area of over 4,000,000 square miles, a greater surface than that of Europe, or of the United States and Alaska combined. This great area is reputed to support a population of upwards of 400,000,000; figures, however, which I will later point out to be, in my belief, a gross exaggeration, but the balance, even after the most conservative reductions, will still easily be the greatest single contiguous conglomeration of people under one ruler. Racially speaking, they are a conglomeration. Who the Chinese were originally is not known. It is generally believed that they came from Western or Central Asia, and, conquering the scattering nomadic tribes inhabiting what is now China, seized their country.

In the dependencies and Chinese proper we find distinctly different peoples, with their individual customs; while scattered about the empire proper are settlements of strange tribes, whose origin is absolutely unknown but who are believed to be relics of the aboriginal inhabitants.

Lack of intercommunication has allowed the language of the Chinese to become locally varied, and to such an extent, that although the written characters are the same, the spoken dialect of the North and South are so different as to be mutually unintelligible. There are said to be in the empire proper eight dialects, each again being many times subdivided by local colloquialisms. Of these dialects the most important is the so-called Mandarin or Pekingese, the dialect of the North and the official language of the country, for it is the one which all government officials are required to learn and use. It therefore holds the position in respect to other dialects that the French formerly held in Europe as the Court tongue, or language of diplomacy and officialism.

Historically, China enjoys the distinction of being the oldest continuing nation in the world. Fairly authentic records trace back the course of events to about 3,000 years B. C., so that it rightly claims an existence of at least 5,000 years. Previous to this period there is a vast amount of legendary matter in which probability and fiction have not yet been separated.

China's own historians, with characteristic conceit, make out their country's history to be contemporaneous with time. Owing to her seclusion and isolation from the affairs of other nations, China's history possesses a local rather than a world's interest, and for the most part is a record of the rise and fall of the several tribes or peoples going to make up the nation, each such change establishing a new dynasty. However, there are certain epochs of general interest and certain salient points in the nation's development and growth that should be understood and kept in mind if any study of China or of things Chinese is undertaken.

Accepted Chinese chronology begins with the reign of Fuh-hi in the year 2852 B. C. As to the significance of that date it is interesting to note that it is four hundred years before the rise of the Egyptian monarchy, five hundred years before that of Babylon and precedes the reputed time of Abraham by a period almost as long as the whole record of English history, from the conquest to the present time.

In the Chau Dynasty, which lasted from B. C. 1122 to B. C. 249, we find the great period in Chinese literature, an era comparable with that of Elizabeth in our records. In 550 B. C. Confucius was born, whose philosophical reasonings, owing to the long time he antedated the spread of Christianity and Mohammedanism, have affected the thought of more human beings than the writings or sayings of any other man, with the possible exception of Buddha.

Although Confucius is the central figure of the epoch, there are at least two other men substantially contemporaneous with him, and who are but only a little less prominent, Liao-tze, who preceded him fifty years, and Mencius, who followed him one hundred years. The former was a religious philosopher, on whose writings there has been founded the doctrine of Taoism. This philosophy is based on Reason (Tao) and Virtue (Teh), and is of interest in that it leans towards an eternal monotheism. According to his theory the visible forms of the highest Teh can only proceed from Tao, and Tao, he says, is impalpable, indefinite. Taoism, therefore, contemplates the indefinite, the eternal and a pre-existent something which Liao-tze likens to the 'Mother of all things,' or what we call a creator.

In Chinese literature there are the nine classics, the five greater and the four lesser books. The former are Yih-King, the Book of Changes; Shu-King, Historical Documents; Shi-King, the Book of Odes; Li-Ki, the Book of Rites, and Chun-Tsin, a continuation of the Shu-King. Of

the above, the second, third and fourth, although long antedating Confucius, were edited by him, while the fifth is from his pen. The four lesser classics are Ta-Hioh, Great Learning; Chung-Yung, the Just Medium; the Analects of Confucius; and the writings of Mencius. The last is the great production of Mencius, while the first three are a digest of the moralizings of Confucius as gathered by his disciples.

On these nine books are founded Chinese philosophy, morals, thought, religion, education, ethics and even etiquette. The spirit of the matter in the classics is essentially lofty, moral and good.

In China, learning transcends all else in importance, and as Confucius is considered as the fountain head of literature and learning, so he has become to be regarded as Europeans in the Middle Ages regarded saints, and temples to his honor are found in all large cities. The most important is the beautiful example of Chinese architecture in Peking, where the Emperor annually worships before his tablet. In spite of this apparent adoration, Confucius is not regarded by the Chinese as a god, but is clearly understood by them to have been a man, a philosopher and the embodiment of wisdom, and is revered as such. He was not the founder of a religion, nor was he a religious writer, although his sentiments have become woven in the complicated fabric of Chinese faith. The name by which foreigners know him is a latinized corruption of Kung-tze, the Master Kung, the last being his family name, as Mencius is a similar corruption of Mang-tze, the Master Mang.

Following the Chau dynasty comes that of Tsin, which was noted for supplying the foreign appellation of the country and for the great works, both good and bad, of its name-giving Emperor. It was he who united the various peoples of Eastern Asia under one sway; laid the foundation for at least internal commerce by beginning the construction of the Chinese system of canals, started the construction of the Great Wall and succeeded in raising his country to a point of material greatness not before reached. Then, with a view to make all records begin with him, he ordered burned all books and writings of every description, including those of Confucius and the other philosophers. Fortunately, in spite of an energetic attempt, this sacrilegious act was not completely consummated.

From this period to the Tang dynasty in 618 A. D. the history of this country is a succession of different reigning houses, internal wars, rebellions, more or less successful, and during which the capital was frequently moved, part of the time being located at Nan-king on the Yang-tze, which many of the Chinese of to-day regard as the proper site. The great single event of this long stretch of years, and practically the only one of foreign interest, was the introduction of Buddhism at the close of the first century A. D.

The Emperor Ming-ti sent an embassy to the West to bring back the

teachings of the foreign god, rumors of whose fame had already reached the Pacific shore. It has since been supposed by some that this meant tidings of Christ; but the basis for such an inference is doubtful. At any rate the embassy found its way to India and returned thence with the doctrines of Buddhism, which at once became the established religion of the country, spreading over the whole of China and eventually Japan. It makes an interesting speculation to consider what the effect on the world would have been if the embassy had taken a more northern route, bringing it to Palestine instead of to India.

The Tang dynasty A. D. 618 to 908 marks perhaps the zenith of Chinese development, when, there is no doubt, its civilization and cultivation outshone those of Europe at the same period. Literature flourished; trade was nurtured, the banking system developed, laws were codified and the limits of the empire were extended even to Persia and the Caspian Sea. The art of printing was discovered, certainly in block form and probably by movable type. The fame of China reached India and Europe, whence embassies were despatched bearing salutations and presents. Monks of the Nestorian order were received by the Emperor Tai-tsung, who gave permission for them to erect churches, and thus was Christianity first publicly acknowledged in China. Although the efforts of the Nestorian monks continued for many years from perhaps as early as 500 A. D. to 845, yet they were without permanent results, as they left no monuments behind them, and the practice of Christianity was suspended for some centuries.

In 1213 A. D. the Chinese for the first time passed under a foreign rule, when Genghis Khan, the great Mongol, crossed the wall and began to lay waste the country. When he had captured Peking and established a Mongol dynasty, he turned his attention to further conquests, and in 1219 led a force westward. With it he overran Northern India, Asia Minor, and even entered Europe in Southern Russia. He then withdrew to Peking, having established the largest empire in the world's history. Under his degenerate successors this vast power dwindled, the only permanent result being found in Europe; for the presence of the Turks on that continent is due to the invasion of Genghis, as he drove them before him out of their own Asiatic country.

The last purely Chinese dynasty was the Ming (Bright) which occupied the throne from 1368 to its overthrow by the Manchus in 1644. The capital of this house was originally at Nan-king, but was moved by the great Emperor Yung-loh to Pekin in 1403, where he constructed the famous Ming Tombs forty miles northwest of the city, where he and his successors of Ming lie buried in solitary grandeur. He also established the laws under which China is governed to-day, and under him the seeds of Christianity were permanently planted in China in 1582 by the Jesuit missionary Matteo Ricci. About two hundred and

fifty years before a temporary foothold had been gained by the same order. The first effort lasted, however, for but seventy-five years, and then, like the Nestorian movement, quietly died without practical results. It was also during this dynasty that the first foreign settlement was made on Chinese soil, in the Portuguese port of Macao in 1557.

In the seventeenth century the northern tribes set up a rebellion. Gaining adherents to their cause they captured Peking in 1644, swept away Chinese rule and established a Manchu dynasty, to which they gave the name of 'Ta Tsing' or the 'Great Pure.' The principal effects of this change were to establish the northern races in control of the government and to stamp upon the whole people their most striking outward distinguishing mark in the queue, which was a distinctly Manchu custom, the Chinese having cut their hair like Western people. On their establishment the Manchu rulers ordered all people to wear the queue as a token of subjugation which the Chinese natives still do, although the Tibetans and Mongols continue to cut their hair as of old. Manchus and Chinese can be readily recognized by their names. Thus one of Manchu descent has but a double name, like Tung-lu, while a Chinese has three characters as, Li Hung-chang.

The government of China is an absolute imperialism, with powers vested in an Emperor, whose position is well indicated by his most used title, the 'Son of Heaven.' He is assisted by two councils under whom are the seven boards of: Civil Service, Revenue, Rites, War, Punishment, Works and Navy, who severally attend to the administration of affairs in their respective departments. Then there is the Tsung-Li-Yamên, or foreign office; a bureau composed of twelve ministers, with and through whom all relations with other nations and foreigners generally are conducted.

The communication between the Imperial authority and the people is through the local governments of the provinces. These provinces in their organization closely resemble an American State, varying in size from Che-kiang, the smallest, within an area of 35,000 square miles, to Sz-chuen, the largest, embracing 170,000 square miles. These are respectively comparable with the States of Indiana (36,350 square miles) and California (156,000 square miles). Each province is ruled by a governor appointed by the throne, and he exercises his authority through a chain of officialism. The province is divided into circuits, each circuit being controlled by an intendant of circuit or taotai. In addition to the regular taotais, there are special ones appointed to look after the large treaty ports, like Shanghai. Such taotais have immense powers and the positions are much sought after. The circuits or 'Fu' are usually again subdivided into two or more 'Chau' or prefectures under a prefect, and each perfecture into Hsiens or districts, under a magistrate. Cities where such officials dwell are usually indicated by adding 'Fu,'

'Chau' or 'Hsien' to their names. The Hsien magistrates are the men who come in direct contact with the people. The Governor in turn reports to an officer properly styled a Governor-General, but whose title foreign nations have translated as Viceroy, each of whom usually controls two provinces. These Viceroys form the real government of the country. Their powers are absolute. It is to them, armed with judgment of life and death, that the people look for justice and protection, and to them, also, the throne itself looks for support. Each Viceroy maintains his own army, in some instance a portion of which has been foreign drilled, which army he has a right to decide whether he will use for national purposes or not.

Of the existing college of Viceroys, there are three who have brought themselves by their acts, abilities and force of character to the forefront, and who are known as the three great Viceroys. These men are Li Hung-chang, formerly Viceroy of Pe-chi-li, but now of Canton, ruling the provinces of Kwang-tung and Kwang-si, and so usually referred to as the Viceroy of the two Kwang; Chang Chi-tung, the Viceroy of Wu-chang, in like manner called the Viceroy of the two Hu, as his dominion covers the provinces of Hu-peh and Hu-nan, and Liu Kun-yi, the Viceroy of Nan-king, ruling the provinces of Kiang-su and Ngan-whui.

Li Hung-chang, whose reputation is international, needs no introduction. The other two, while, perhaps not so well known, are in China of scarcely less importance, especially as they have a personal hold on their people that is not equaled by any other official. They are not rich, which is almost the same as saying that they are honest, and, although they are decidedly pro-foreign in their views, nevertheless they are at the same time imbued with a strong and earnest desire to ameliorate the condition of their charges and, therefore, are honored and respected by their people. To accomplish this end they do not hesitate to avail themselves of occidental ideas or means if therein they see a possibility of benefit.

When the Empress Dowager in 1898 executed her *coup d'etat* and notified the Viceroys of what she had done, Chang Chi-tung and Liu Kun-yi were the only ones who had courage to express their disapproval. In consequence there is little doubt that she would have removed or beheaded them if she had dared to brave the outcry of the people of the four provinces, which would certainly have followed. In any reorganization of China these three men will play an important part in which the influence of Chang Chi-tung and Liu Kun-yi will certainly be of weight as they enjoy the esteem and confidence of both foreigner and native.

In the appointing of all officials there is one rule that is curiously indicative of Chinese reasoning and methods. No official is allowed to

serve in a district in which he was born. The reason for this is that, being a stranger, without local prejudice or interest, it is believed that he will administer justice quite impartially. Unfortunately, human nature being the same in China as elsewhere, the official, on account of his lack of local prejudice, administers justice in such a manner as will best promote his own interests and secure his advancement.

Topographically considered, China lies on the eastern flank of the great Central Asian plateau and, therefore, its main drainage lines lie east and west. There are three great valleys: that of the Yellow, in the north; Yang-tze in the center; and the Si (or West), in the south. The Yellow River, or Hoang-ho, or as it is frequently called, on account of its erratic and devastating floods, 'China's Sorrow,' is a stream very much resembling the Mississippi, carrying a great amount of alluvium, which it deposits at various places, forming bars and shoals. In order to protect the shores from inundations, the Chinese for many years have been building dykes with the result of gradually raising the bottom of the river through the deposition of alluvium. There are now many places where the bottom of the stream is actually higher than the normal banks. Under such circumstances the breaking of a dyke means untold destruction, with possible permanent change of bed. The location of its mouth shows the character of this great river. Eighty years ago it flowed into the Yellow Sea, south of the Shang-tung Peninsula. To-day it enters the Gulf of Pe-chi-li two hundred and fifty miles in a direct line northwest of its previous location, or about six hundred miles, when measured around the coast line. The Yang-tze, on the other hand, rightly merits its name of 'China's Glory.' This noble stream, whose length is about 3,500 miles, of which 1,100 miles are navigable by steam vessels, divides the country, approximately equally north and south. Its drainage area covers more than one-half of the empire, the richest and most valuable portion. This stream, like the Hoang-ho, carries a large amount of alluvial matter, but it is much more orderly and well regulated. Practically at its mouth, the gateway to Central China, although actually on a small tributary called the Wang-Poo, is Shanghai. The West River, or Si-Kiang, drains the southern and southwestern section of the empire, flowing into the sea at Canton, where with the Pei (North) and Pearl rivers it forms the broad estuary known as the Canton River.

In agricultural possibilities and mineral wealth China is particularly fortunate. On account of its great dimensions north and south it enjoys all varieties of climate from the tropical to the temperate, and in consequence possesses the ability to raise almost any crop. The great bottom lands of the Yang-tze, Hoang and other rivers, which are subject to annual overflow, are thus by nature enriched and automatically fertilized as are the bottom lands along the Mississippi and other allu-

vium-bearing streams. In addition to the ordinary advantages of soil and variety of climate to which such a large expanse is naturally entitled, China enjoys one special favor in the singular deposit known as Loess.

The country lying north from the Yang-tze to the Gulf of Pe-chi-li, part of which area has been made by the alluvial deposits of the Yang-tze and Yellow rivers, is known as the Great Plain. Of this territory there is a considerable section in the provinces of Shen-si, Shan-si and Shan-tung, which is known as the Loess formation. This particular soil is yellow in appearance, resembling alluvial material, but on examination is found to consist of a network of minute capillary tubes. The best theory for its deposit is that it is the fine dust of dried vegetable matter carried down by the winds from the northwest plains and dropped where found. The fine tubes are accounted for by believing them to be the spaces occupied by the roots of grasses, as the latter have been continually raising themselves to keep on the consequently rising surface. The Loess soil is of great and unknown thickness, of extraordinary fertility and with great capacity for withstanding droughts, as the tubes by their capillary action serve to bring up moisture from the ground water below. This part of the Great Plain has been supplying crops for many centuries without fertilizing and supports the densest part of the Chinese population.

In minerals, China is particularly rich. Of the precious metals, gold and silver are known to exist, and probably in paying quantities, while of the less valuable metals, copper, lead, antimony and others have been found, and but await the introduction of proper transportation methods to be developed. Petroleum occurs in Sz-chuen, the extreme western province lying next to Tibet. But China's greatest mineral wealth lies in iron and coal. The great fields of the latter are in Pe-chi-li, Shen-si, Shan-si, Sz-chuen, Kiang-si and Hu-nan, where all varieties from soft bituminous to very hard anthracites are found. Of the former there are coals, both coking and non-coking, fit for steel-making or steam uses, while of the latter there are those adapted for domestic use, with sufficient volatile matter to ignite easily, and others sufficiently hard to bear the burden in a blast furnace and sufficiently low in phosphorus, sulphur and volatile substances to render them available for the manufacture of Bessemer pig, as is done in Pennsylvania. Chinese houses are usually without chimneys, and, therefore, the native is compelled to use for domestic purposes an anthracite, or, as he calls it, a non-smoking coal, which he burns in an open fireplace, the products of combustion escaping through the doors, unglazed windows or the many leaks which are usually found in Chinese roofs.

In opposing the introduction of occidental reforms, methods and commercial relations, China has invited, if not actually obliged, the

forming of bases by other nations from which to push their trade. Chinese soil is now held, through some excuse and under various conditions, by Portugal, Great Britain, France, Germany, Russia and Japan. In addition to this Italy has made an unsuccessful attempt to secure a foothold at San Mun Bay.

The Portugese possession is Macao, situated on the western side of the mouth of the Canton River, a charming settlement covering the city and a few square miles of territory separated from the main land by a narrow neck. It is a delightful little piece of southern European refinement in an Oriental setting, and perhaps the only point on the coast to which the word charming can be rightly applied. It was the first foreign settlement in China, being ceded to Portugal in 1557 in return for services in putting down pirates. On account of the shallowness of the harbor, the importance of Macao as a trading point or military base is very small.

The British possessions are Hong Kong, Kow-loon and Wei-hai-wei. As a result of the Opium War of 1841, the island of Hong Kong, whose greatest dimension is but nine miles, and wholly mountainous, located at the eastern side of the Canton estuary, directly opposite to Macao, but distant therefrom about forty miles, was given over by China as a part of the indemnity. In 1860 there was added the shore of the main land, called Kow-loon, across the roadstead whose width is rather more than a mile, in order to complete the harbor. On this island the English have established a colony, built the city of Victoria, and through the magnificent land-locked harbor, have developed a trading point, whose commerce ranks with that of the world's greatest ports. There are no customs dues, no restricting conditions—all nations and nationalities have an equal footing, so that Hong Kong has become the great *entrepôt* or warehouse for nearly the whole of the Orient, and absolutely so for Southern China, whose gateway it controls. A year's record shows that over 11,000 vessels enter and clear, not including upwards of 70,000 junks. Thus have the English converted an apparently useless island into a most valuable possession for themselves and a great stepping-stone for the world's commerce.

The next country to establish a foothold on Chinese soil was France, who acquired from Annam, by war and treaty, between the years 1860 and 1874, part of the province of Tong-king. In 1882 further trouble arising between France and Annam, the latter appealed to her protector, China, and war ensued. The result was the permanent occupation of the whole of Tong-king and the placing of the French frontier next to that of China.

At the conclusion of the Japanese war, the island of Formosa was permanently ceded by China and an arrangement made for the temporary occupation of Port Arthur. Then Russia interfered, insisted on

the withdrawal of the Japanese troops from the North, and, as her price for aiding China, secured a lease for twenty-five years of the Liao-tung Peninsula, covering eight hundred square miles, including the harbors of Port Arthur and Talien-wan, and so, practically obtained the control of Chinese Manchuria.

In 1897 two German missionaries having been killed, the German Emperor demanded as compensation a share of Chinese soil, which was granted through a 'lease' of Kiao-Chau Bay for ninety-nine years.

The following abbreviated quotations indicate the tenor of these curious arrangements:

"I. His Majesty the Emperor of China, being desirous of preserving the existing good relations with His Majesty the Emperor of Germany and promoting an increase of German power and influence in the Far East, sanctions the acquirement under lease by Germany of the land extending for one hundred li at high tide.

"Germany may engage in works for the public benefit, such as waterworks, within the territory covered by the lease, without reference to China. Should China wish to march troops or establish garrisons therein she can only do so after negotiating with and obtaining the express permission of Germany.

"II. His Majesty the Emperor of Germany being desirous, like the rulers of certain other countries, of establishing a naval and coaling station and constructing dockyards on the coast of China, the Emperor of China agrees to lease to him for the purpose all the land on the southern and northern sides of Kiao-Chu Bay for a term of ninety-nine years. Germany is to be at liberty to erect forts on this land for the defense of her possessions therein.

"III. During the continuance of the lease China shall have no voice in the government or administration of the leased territory. It will be governed and administered during the whole term of ninety-nine years solely by Germany, so that the possibility of friction between the two powers may be reduced to the smallest magnitude.

"If at any time the Chinese should form schemes for the development of Shan-tung, for the execution of which it is necessary to obtain foreign capital, the Chinese government, or whatever Chinese may be interested in such schemes, shall, in the first instance, apply to German capitalists. Application shall also be made to German manufacturers for the necessary machinery and materials before the manufacturers of any other power are approached. Should German capitalists or manufacturers decline to take up the business, the Chinese shall then be at liberty to obtain money and materials from other nations."

While the area actually covered by the lease is small, the shore line being but one hundred li (thirty-three miles), nevertheless the Germans have thrown a sphere claim over the whole province of Shan-tung, an

area as large as New England, based on the special commercial concession, as above quoted.

The strongholds of Kiao-Chau and Port Arthur, for the Germans and Russians immediately set about fortifying them, so threatened the balance of power in the North, that the British government in 1898, demanding something to offset them, secured the harbor of Wei-hai-wei, directly opposite Port Arthur and with it marking the entrance to the Gulf of Pe-chi-li. This territory is to be held as long as the Russians hold Port Arthur. At the same time Great Britain extended the limits of the Kow-loon possession by two hundred square miles, so as to absolutely protect the harbor of Hong Kong, and secured from the Chinese government a promise that no territory in the Yang-tze Valley should be alienated to any other power, thus obtaining a so-called sphere of influence over the richest half of the empire. France, not wishing to see her commercial rivals outdo her, demanded, as her share of the plunder, the harbor and port of Kiang-chau-wau near her province of Tong-king and secured a lease of the same for ninety-nine years. Thus has the Chinese government given away its patrimony.

In addition to the above possessions of territory actually held under the domination of their respective governments, there are at the various treaty ports the so-called foreign concessions, which have been given by the Chinese government to the temporary care of the people of other nationalities, permitting them to establish a police force, courts of justice, fire protective service, to collect taxes for local use, and otherwise to maintain local governments according to foreign regulations and practically without interference by the Chinese government. Such concessions remain, in name, at least, Chinese territory. The largest and most important of them is Shanghai, where grants were made some years ago to the English, American and French. The first two have been combined into the Shanghai municipality, under a system of popular government with annual elections, where the rate-payers are voters and which in all functions closely resembles an independent republic. The theory that all nations are on an equal footing within the limits of the municipality is carried out to such an extreme that not only does the Chinese government maintain a post-office, but so also do all other countries whose citizens operate lines of mail steamers to and from the port. There are thus to be found, in addition to the Chinese post-office, regular establishments of the United States, Great Britain, Germany and Japan, while France has hers in the French concession, at all of which the stamps of the several countries are for sale.

Such in a few words is the political and physical status of that nation and that country on which the attention of the civilized world is focused, and whose development and regeneration will probably be the leading feature of the early years of the new century.

RESCUE WORK IN HISTORY.

By President DAVID STARR JORDAN,

LELAND STANFORD, JR., UNIVERSITY.

AT the November meeting of the Astral Camera Club, Mr. Asa Marvin presiding, Prof. Abram Gridley, the learned master of the Alcalde Union High School, spoke on the unique topic of his proposed 'Rescue Work in History.'

He began with the bold declaration that the two great discoveries, twin triumphs of the human mind, which will make this age memorable, were these, the Banishment of Space and the Annihilation of Time. He proposed to illustrate the results of these discoveries and to show how they could be turned to the advantage of mankind by means of an esoteric foray through the echoing aisles of the past.

"It has been shown by the great Dr. Hickok," said Professor Gridley, "that matter is but a portion of space filled with a modicum of 'force, which is actively engaged in holding itself still.' When this activity becomes passive, matter is no more. Thus as matter has no real existence, space, which is its matrix, is banished also from the category of realities.

"Even more remarkable is the discovery of the famous Dr. Hensoldt that time could be literally 'rolled away as a scroll,' and therefore practically annihilated. This fact is stated in these memorable words: 'We count our time by the rotations of our planet. If you were to go close to the north pole and then travel around it in a westerly direction you could walk back all the lost days of your childhood. And if you are moderately swift-footed you might run around that pole until you caught the earth where it was when Julius Cæsar first landed in Britain or when the pyramids were built."

"Only this year," continued the learned schoolmaster, "has the practical significance of all this been brought to light." Referring to the phenomena of thought-transference, our friend and guide, the venerable sage of Angels, spoke before us these words:

" 'All manner of sensations,' Mr. Dean has told us, 'may be transmitted, and these over any distance or through any time. It is as easy, for example, for me as an adept to speak to Marcus Brutus as for me to speak to the Lama of Thibet, and equally easy for Plato or Ptolemy to speak to me. Through this power I may yet dissuade Brutus from his awful deed or save Cæsar from that ambition through which fall the

emperors and the angels. In history nothing is too late and the great tangled fabric of the past is ever open to reconstruction.'

"With all this knowledge gained," said Professor Gridley, "the work of these adepts should not lapse for want of initiates bold enough to act." He proposed that the Astral Club add to its purposes that of serious effort in the direction formerly occupied by space and time. His thought was nothing less than the perfection of the human race through the correction of history. This could be best accomplished by collective personal influence on the lives of great men. The value of such influence all teachers must admit. That it is not too late is now a certain fact, and to work in unison is to do the best work.

Mr. Dean had already devoted many esoteric and soulful hours to this labor, but he had used only the method of telepathy, subtle enough in its action, but not powerful enough for large results. Because it is dependent on etheric vibrations and electric inductions, it is practically ineffective except in settled weather. The turbulent atmosphere of the Middle Ages renders settled communication difficult if one tries to go back far enough for his influence to be worth while. It is also much better to use personal presence than any form of esoteric induction, if the former is possible.

If you wish a thing to be well done, the great Franklin assures us, you must do it yourself, and few of us moderns could speak with higher authority on electrics and etherics than he. The mere extension of a personal aura backward through history, Mr. Dean has privately admitted, fails of the highest results, and nothing short of the best can be satisfactory to the initiates of Alcalde. Still less can we count on projecting such an aura into the future. The forms of men and nations of future centuries are now in Devachan, in the subastral or plastonebulose state. A human aura can have little definite influence upon them, especially because, not knowing what influence should be exerted, the sensator would work in utter astral darkness which could yield no tangible result. It is evident that this great work needs the personal presence. How to produce this Dr. Hensoldt's discovery clearly indicates.

If we go around the earth from west to east, as the sun seems to go, we have added one whole day for each revolution. If we go to the high north, the circles grow shorter, and barring certain difficulties in transportation, it is easier to go around. If we ascend to the very pole, which by the aid of the non-friable astral body is not so very difficult to adepts, we find a circle of revolution only a few feet in circumference.

"Let us suppose," continued Professor Gridley, "that we have arrived at the north pole on the first day of August. A single circuit around it to the eastward and we reach the second of August. A dozen circuits and we have August the fourteenth. With the aid of the

mechanical skill now so easily acquired it will be easy to prepare an electric turn-table by which these revolutions can be accomplished. This can be set in rotation by the electric force of the Northern Lights. Seated upon its edge and whirled eastward for a dozen minutes, one would find himself, perhaps, in the midst of the twenty-sixth century. Then turning southward to the abodes of men, the adept would be received with the greatest eagerness. To these far-off people, 'the latest progeny of time,' he would appear as a Mahatma wise to overflowing with the lore of bygone centuries. It is even possible that such an invention was already in the hands of the ancient Mahatmas. Of such origin beyond a doubt were the sages or Old Men of the Mountains, who from time to time in the past have appeared in the cities of men, filled with forgotten information and equipped with magic power. Such a one of a surety was Trismegistos, three times greatest, and such was Peter the Hermit and Gautama. In the light of our present knowledge, the appearance of Van Winkle at the town of Falling Waters should be carefully reinvestigated. The explanation currently given is far from conclusive, and the little men of the Catskills were probably of an astral nature and not contemporaneous with the ignorant villagers who scoffed at their existence.

"But far more important than any result from the projection of the personal presence into the future are those derived from its retrojection into the scenes of the past. For this purpose the machinery of the turn-table should be attuned to the greatest possible accuracy. Its movement must be as perfect as that of the finest chronometer. A whirl or two too much or too little might leave the personal presence stranded in an age on which its influence would be wasted. For instance, the attempt to rescue Cæsar from his ambitions or Brutus from his crime would be futile if attempted before Cæsar was born. A single day too late and the whole matter must needs be gone over again from the first, with large chances that the drifting floes of the North may have swept away the turn-table. In such case the painful journey on foot round and round the pole till the desired meridian is reached would be inexpressibly tedious. Even the most eager adept could hardly be blamed if he directed his steps toward his own century and his bodily home. To prevent gross accidents and to secure the best results, therefore, a considerable number of people should cooperate. We should make of the matter a kind of Salvation Army. Seated on the turn-table a hundred adepts could be whirled round and round to the westward, each descending at the time his mission might designate. Miss Jones, for example, would descend in 1776 to gain the confidence of Benedict Arnold and thus save him from his treason. Our friend, Doctor Cribbs, perhaps could descend in the reign of James II., and by a few doses of Swamp Root cure the judge's sad malady and save

England from the strain of the Bloody Assizes. Mr. Marvin could muffle the bell of St. Germain l'Auxerrois and the name of St. Bartholomew would lose its dark suggestion. Miss Lucy Wilkins could leave us to the north of Cologne and in the time of St. Ursula. This good woman could be turned from her useless quest and her sad host of martyred virgins could each become a German Hausfrau. Again, our fair friend from Fidèletown, Miss Violet Dreeme, could find scope for her powers in the rescue of Guinevere. These serve simply as illustrations. We may vary them as we please.

"The preliminary difficulties once surmounted, the auroral turntable once in operation and in the hands of a few hundred adepts, missionaries of the present to the past, the tangled jungles of history would be turned to a field of the Cloth of Gold. By keeping open telepathic connection with the esoteric clubs at home, we can inform the world that is, of the progress of our work, and the changes we make in history could be announced in our schools.

"Grand indeed is our conception," said Professor Gridley, "and it is not far from realization. The initial expense is but a trifle. A few hundred dollars in tense springs, clockwork and dynamos, a table of the finest rosewood and the service of a skilled mechanic, an adept in electricity and skilled in astral impersonation, and it is done.

"More than this," continued Professor Gridley impressively, "all this is already provided. I have here a letter from the editor of the New York Sunday 'Monarch,' an offer of all expenses and a generous salary in return for the first telepathic advices, going back beyond the present century. For each preceding century, the sum will be doubled. I have, indeed, contracted with the great journal for the exclusive account of my interviews with the great Bacon, whose noble but polluted nature it shall be my life work to redeem."

JAMES EDWARD KEELER.

By Prof. W. W. CAMPBELL,

ACTING DIRECTOR OF THE LICK OBSERVATORY.

THE Lick Observatory has lost an ideal director. Astronomy has suffered a loss it can ill afford. Colleagues and friends widespread will miss a companionship which was simply delightful.

James Edward Keeler was born in La Salle, Ill., on September 10, 1857. Ralph Keeler, his first American ancestor, settled in Hartford in 1635. His father, Wm. F. Keeler, was an officer of the original 'Monitor' at the time of its engagement with the 'Merrimac.' His mother (still living) is the daughter of Henry Dutton, former Governor of Connecticut and Dean of the Yale Law School.

In 1869 the family removed from La Salle, Ill., to Mayport, Fla. Here Keeler prepared for college, under the tutelage of his father and his older brother. Here his fondness for astronomical studies was developed. He established 'The Mayport Astronomical Observatory' in 1875-77. It included, at the least, a quadrant, a two-inch telescope, a meridian circle and a clock. Under date of 1875, September 22, his journal records an observed altitude of *Polaris* secured with 'my quadrant.' Other entries read:

"1875, November 14. Sent to Queen last night for lenses for my telescope."

"1875, November 29. Lenses from Queen came to-night; one two-inch achromatic, and two plano-convex lenses for eyepiece."

"1875, December 12. Directed my telescope to the stars, and saw the rings of Saturn for the first time. . . ."

"December 14. Saw the Annular Nebula in Lyra. One satellite of Saturn. . . . All four of the stars in the Trapezium. . . ."

"1876, January 26. Got up at half-past four this morning and applied my telescope to Jupiter for the first time. . . ."

In 1877, at the age of twenty years, he constructed a meridian-circle instrument. The telescope was that of a common spyglass, 1.6-inch aperture and 13.45-inch focus. The axis was turned out of wood. Brass ferrules, driven on the ends of the axis and turned down, formed the pivots. The wooden circle, 13.3 inches in diameter, was graduated to 15'.*

*Keeler's original sketch of this instrument and his written description of it will be published in the next number of the 'Publications of the Astronomical Society of the Pacific.'

His 'Record of Observations made at the Mayport Observatory' contains beautiful colored sketches of Jupiter, Saturn, Venus, Mars, the Orion Nebula, of double stars and of 'Scenery on the Moon'; and in addition, data of a numerical character. These early drawings are characterized by the refined taste and skill so well known from his later professional work.

Keeler entered Johns Hopkins University late in 1877; and, following major courses in physics and German, he was graduated with the degree of A. B. in 1881. At the end of his freshman year he accompanied Professor Hastings, as a member of Professor Holden's party from the Naval Observatory, to observe the total solar eclipse of July 29, 1878, at Central City, Col. Although his part was the modest one of making a drawing of the corona, his written report on the work is a model scientific paper, and may be read with profit by visual observers of eclipses.

In the spring of 1881 Professor Langley, desiring an assistant in the Allegheny Observatory, requested the Johns Hopkins University to recommend a suitable man for the place. Keeler was named and accepted the appointment, beginning work at Allegheny several weeks before receiving his degree. I was speaking in June of this year (1900) with one of the physicists who had recommended Keeler for the Allegheny position, and the subject of this very appointment came up. "I told Professor Langley," said he, "that one of my strongest reasons for the recommendation is that Keeler doesn't claim to know everything." To the end of his life this charming trait remained unimpaired. It is to Keeler's credit that he largely defrayed his own expenses in college by acting as assistant to some of the lecturers in the experimental courses.

Professor Langley made his noted expedition to the summit of Mt. Whitney, Cal., in June-September, 1881, to determine the value of the 'Solar Constant.' Keeler accompanied the expedition in the capacity of assistant, and carried out his share of the program with skill and efficiency. Returning at once to Allegheny, his work until May, 1883, was closely related to the many problems arising from the Mt. Whitney expedition.

The year 1883-84 was devoted to study and travel abroad. The months of June, July and August, at Heidelberg, were given to the study of light and electricity under Quincke, chemistry under Bunsen, and integral calculus under Fuchs. In the winter semester in Berlin he heard the lectures on physics by Helmholtz and Kayser, on differential equations by Runge and on quarternions by Glan. His main investigation in the physical laboratory was on 'the absorption of radiant heat by carbon dioxide'—a problem suggested no doubt by his Mt. Whitney experiences.

From June, 1884, to April, 1886, Keeler again served as assistant in

the Allegheny Observatory, affording most efficient help to Professor Langley in his classical researches on the lunar heat and on the infra-red portion of the solar spectrum.

Early in 1886, on Professor Holden's recommendation, Keeler was appointed assistant to the Lick trustees. He arrived at Mt. Hamilton on April 25, 1886, and immediately proceeded to establish the time service. The telegraph line to San José was perfected, the transit instrument, the clocks and the sending and receiving apparatus at both ends of the line were installed. The signals were sent out on and after January 1, 1887, north to Portland, east to Ogden and south to San Diego and El Paso. In addition to the time service, he assisted the trustees in installing the various instruments.

When the observatory was completed and transferred to the regents of the University of California, on June 1, 1888, Mr. Keeler was appointed astronomer: the original staff consisting of Astronomers Holden, Burnham, Schaeberle, Keeler and Barnard, and Assistant Astronomer Hill.

Professor Keeler was placed in charge of the spectroscopic work of the observatory. The large star spectroscope, constructed mainly from his designs, has no superior for visual observations. Of the many results obtained with this instrument we may mention the observations of Saturn's rings and Uranus, with reference to their atmospheres; of the bright and dark lines in the spectra of γ Cassiopeiæ and β Lyræ; of the color curve of the 36-inch equatorial, and of the spectra of the Orion Nebula and thirteen planetary nebulæ.

His beautiful observations on the velocities in the line of sight of these fourteen nebulæ mark a distinct epoch in visual spectroscopy. His memoir on the subject took its place as a classic at once. The probable error of the final result for each nebula, based on the mean of several observations, is only 3.2 kilometers per second. Attention should be called to one extremely important fact established by these measures, viz., the velocities of the nebulæ in their motion through space are of the same order of magnitude as the velocities of the stars.

The recognition of the fact that a great refracting telescope is also a most powerful spectroscope for special classes of objects, by virtue of the chromatic aberration of the objective, is due to Professor Keeler. Among the first objects observed with the 36-inch equatorial were the planetary nebulæ and their stellar nuclei. The observers were struck with the fact that the focal length for a nebula is 0.4 inch longer than for its stellar nucleus; a discrepancy which Professor Keeler at once explained by recalling that the star's light is yellow, whereas that of the nebula is greenish-blue.

Astronomical readers will remember Keeler's splendid drawings of the planets Saturn, Jupiter and Mars, made with the assistance of the

36-inch telescope during 1888-90. His faithful and artistic drawings of Jupiter have no equal.

He was in charge of the very successful expedition sent by the Lick Observatory to Bartlett Springs, Cal., to observe the total solar eclipse of January 1, 1889.

Professor Keeler resigned from the Lick Observatory staff on June 1, 1891, to succeed Professor Langley as director of the Allegheny Observatory, and professor of astrophysics in the Western University of Pennsylvania. The Allegheny Observatory has perhaps the poorest location of any observatory in this country for spectroscopic work. But in spite of this disadvantage Keeler's investigations continued and promoted the splendid reputation established for the observatory by his predecessor. He comprehended the possibilities and limitations of his situation and his means, and adapted himself to them. His spectroscopic researches were largely confined to the orange, yellow and green regions of the spectrum, since these would be less strongly affected by the smoky sky for which that vicinity is famous.

The Allegheny spectroscope, designed and constructed soon after his acceptance of the position, contained several valuable improvements. The use of three simple prisms in its dispersive train was a departure which has been followed with great advantage in many later instruments. With this instrument he made an extensive investigation of the Orion Nebula and the stars immersed in it, establishing the fact that the nebula and the stars are closely related in physical condition.* His beautiful observations of Saturn's rings, proving that they are a cluster of meteorites—myriads of little moons—have never been surpassed in interest in the entire astronomical field. These observations are so well known to every one interested in astronomy that one sentence suffices. He proved spectrographically, using the Doppler-Fizeau principle, that every point in the ring system is moving with the velocity which a moon would have if situated at that distance from the planet. Professor Keeler's main piece of work at the Allegheny Observatory, on the spectra of the third (Secchi) type stars, remains unpublished, but the measures and reductions are left in an advanced stage.

The regents of the University of California appointed Professor Keeler to the position of Director of the Lick Observatory on March 8, 1898. The ties which bound him and his family to Allegheny were difficult to sever; but the greater opportunities offered by the instruments and the atmospheric conditions at Mt. Hamilton decided him in favor of accepting the appointment. He entered upon his new duties on June 1, 1898.

Without making any rearrangement of the work of the staff, but

* Simultaneous observations of the same object made at another observatory led to the same conclusion.

affording them every possible encouragement to continue along the same lines, Professor Keeler arranged to devote his own observing time to the Crossley reflector. He recognized that the instrument was not in condition to produce satisfactory results. He made one change after another, overcoming one difficulty after another, until, on November 14, he secured an excellent negative of the Pleiades, and on November 16 a superb negative of the Orion Nebula. The enormous power of the reflector in nebular photography was established, and he entered upon the program of photographing all the brighter nebulæ in Herschel's catalogue. More than half the subjects on the program have been completed. The observatory possesses a set of negatives of the principal nebulæ which is priceless and unequaled. These photographs have already led to many discoveries of prime importance; and they furnish a vast amount of material for future investigations of questions bearing especially upon the early stages of sidereal evolution. The photographs record incidentally great numbers of new nebulæ—as many as thirty-one on a single plate covering less than one square degree of the sky. A conservative estimate places the number within reach of the Crossley reflector at 120,000, of which only ten or fifteen thousand have thus far been discovered.

It had previously been supposed that the great majority of nebulæ were irregular and without form, and that only a few were spiral. Professor Keeler's photographs have recorded more spiral nebulæ than irregular ones. This discovery bears profoundly on theories of cosmogony, and must be considered as of the first order.

It is time to refer to Professor Keeler's work as director. I but faintly reflect the views of every member of the staff, and indeed of all who have been interested in the work of this observatory, when I say that his administration was completely successful. He cherished and promoted ideal conditions in this ideal place. He made a success of his own work in a splendidly scientific manner, and he saw to it that every one had all possible opportunities to do the same. No member of the staff was asked to sacrifice his individuality in the slightest degree. Nor were demands made for immediate results: no one's plans were torn up by the roots to see if they were growing. The peace of mind of the investigator, so absolutely essential for complete success, was full and undisturbed. Withal, Professor Keeler's administration was so kind and so gentle—and yet so effective—that the reins of government were seldom seen and never felt.

The elements of his successes are simple and plainly in view. His openness and honesty of character, his readiness and quickness to see the other man's point of view, his strong appreciation of the humorous as well as the serious, and above all, his abounding good sense—these traits made his companionship delightful and charming. Scien-

tifically Professor Keeler never groped aimlessly in the dark. He would not attack a problem until he had as fully as possible comprehended its nature and the requirements for success. With the plan of attack completely considered, and the instruments of attack at hand, the execution of his plans involved little loss of time. The Crossley reflector affords a case in point. Assisted by a fellow in astronomy and by the instrument-maker, he devoted five months to preparing the reflector for turning out the magnificent results which at once followed.

Professor Keeler's published papers have a finish and a ripeness which are rarely seen. His love of the beautiful and his artistic skill are evident in all his work.

To speak of the people who had afforded him encouragement at different times in his life was one of his pleasures. His father's friend, Mr. Chas. H. Rockwell, of Tarrytown, was constant in urging the development of so promising a career. He did not forget Professor Hastings' continual kindness and interest during his college days. He frequently spoke of the great value of Mr. William Thaw's interest and encouragement, both to himself and to the Allegheny Observatory; an interest which was continued after Mr. Thaw's death by other members of his family.

The honorary degree of Sc. D. was conferred upon Professor Keeler in 1893 by the University of California. He received the Rumford Medal from the American Academy of Arts and Sciences in 1898 and the Henry Draper Medal from the National Academy of Sciences in 1899. He was a member of the National Academy of Sciences, an Associate of the American Academy of Arts and Sciences, a Fellow and Foreign Associate of the Royal Astronomical Society, a Fellow of the American Association for the Advancement of Science, a member and officer of the Astronomical and Astrophysical Society of America, an honorary member of the Toronto Astronomical and Physical Society, the president of the Astronomical Society of the Pacific, a member of the Washington Academy of Sciences, and of various other organizations. Professor Keeler was an associate editor of 'Astronomy and Astro-physics' during 1892-94, and editor with Prof. George E. Hale of 'The Astrophysical Journal,' since 1895.

It appears that Professor Keeler had long been a mild sufferer from heart weakness; to run even fifteen steps caused him great physical distress. It is feared that on Mt. Hamilton he worked beyond his strength. His weakness seemed to develop rapidly this summer. He went away from the observatory on July 30, in the best of spirits and with no anxiety, to secure medical treatment and to spend a brief vacation in the northern part of the State. Increasing difficulty in breathing led him to seek skilled treatment in San Francisco on August 10. His dangerous

condition was recognized on the 11th, and on the 12th a stroke of apoplexy proved fatal.

Professor Keeler married Miss Cora S. Matthews, at Oakley Plantation, Louisiana, on June 16, 1891. Of her great sorrow and of the grievous loss to the two children it would be futile to speak.

When the dangerous weakness of his heart was discovered by the physicians, Professor Keeler's main regret was that he would have to leave Mt. Hamilton and its opportunities in order to live at a lower altitude. It is known that he had planned his work with the Crossley reflector far into the future. A small spectrograph which he was most anxious to employ on certain interesting spectra was completed on the day of his leaving the observatory.

The absence of one so old in experience and so ripe in judgment will be seriously felt throughout his profession.

DISCUSSION AND CORRESPONDENCE.

SCIENTIFIC AND LITERARY HISTORIANS.

THE address of Mr. Thomas Ford Rhodes, president of the American Historical Association, on the subject of history, delivered before the midwinter meeting of that body, and published in the 'Atlantic Monthly' for February, has gone forth to the world with a high degree of authority and impressiveness. Nevertheless, there are some members of the Association—the writer humbly trusts enough to make a large majority—for whom the president does not speak, and who dissent widely from his views.

Mr. Rhodes begins by representing himself as an advocate 'holding a brief for history,' and proceeds to make important concessions to those who refuse it a place in the front rank of subjects of human thought. "It is not the highest form of intellectual endeavor; let us at once agree that it were better that all the histories ever written were burned than for the world to lose Homer and Shakespeare." One more concession yields "to the mathematical and physical sciences precedence in the realm of intellectual endeavor over history." But, having admitted so much, Mr. Rhodes is still of the opinion that the historian's place in the field remains secure. Why he thinks so is not made quite clear. It is true enough that there has never been 'so propitious a time for writing history as in the last forty years'; that 'there has been a general acquisition of the historic sense'; that 'the methods of teaching history have so improved that they may be called scientific'; and that 'the theory of evolution is firmly established.' There is, however, in all this nothing to attract the youth conscious of intellectual strength and brimming with energy and courage to a study which cannot claim to rank among the highest forms of intellectual endeavor. Shall we suppose that the historian's 'place in the field remains secure' only because the giants do not care to wander that way? If so, those who love history better than they love the historians will find little satisfaction in this security.

But, following Mr. Rhodes further, one finds the apparent gist of his contention to be that the new thought throughout the country, which has resulted in better work in almost every direction, has had no such result in historiography; that "with all our advantages" we do not "write better history than was written before 1859, which we may call the line of demarcation between the old and the new," and that Thucydides and Tacitus are still the best models for the historian. The whole address appears to breathe the spirit of a somewhat over-reverent devotion to the Classics, and the hearers may well have imagined that they were listening to an appeal for the study of Greek and Latin. When the Lord of the vineyard comes, there will no doubt be a sufficiently grave indictment against the keepers of the historical portion for the waste they have made of the last eighteen hundred years; but it is hard to believe that they will be found guilty of having failed to improve on the methods of the classical writers.

Has science, then, done nothing for history? Somewhat, even according to Mr. Rhodes himself. In addition to acknowledgments already quoted, he goes on to say: "The publication of the 'Origin of Species,' in 1859, converted it (the theory of evolution) from a

poet's dream and philosopher's speculation to a well-demonstrated scientific theory. Evolution, heredity, environment, have become household words, and their application to history has influenced every one who has had to trace the development of a people, the growth of an institution, or the establishment of a cause." Yet it seems that this has not enabled us to equal the excellence of two or three writers who flourished more than two-thirds of the way back to the dawn of European civilization. Let us at least be frank with ourselves, if such be the fact, and not refuse to recognize the disheartening nature of the conclusion.

There are some iconoclasts, however, who will not accept it; and, if they allowed the barbarian that is in them to speak out, in spite of their high respect and deference for Mr. Rhodes, it would probably assert that there is little hope for the elevation of history to the highest rank of intellectual endeavor by champions so imbued with the spirit of the past. He that would show the subject worth the attention of the most gifted, the strongest and the most penetrating minds can be no worshipper before the marble god of the Classics. He must—difficult as the task would seem to Mr. Rhodes—write history better than Thucydides or Tacitus wrote it. But this is, after all, not so difficult if the proper meaning is given to the words. There are several men living who do it. This I fully believe; and I wish to say that the assertion is made in no spirit of defiance to the standards of my generation, but rather in the spirit of respect for these standards as I see them.

There seems, in fact, to lie some subtle poison in the classics whereby their devotees become intoxicated. Their admiration for the ancient languages and literatures, for the civilizations in which their chosen work lies, appears to grow until they lose faith in the present and depreciate it correspondingly. Modern education, which is aimed to fit, rather than to unfit men for the life they must live, to adjust them to their environment rather than to put them out of harmony therewith, would not be wholly unjustified in entering its *caveat* for all who undertake the study of Greek and Latin.

"If indeed there haunt
About the moulder'd lodges of the Past
So sweet a voice and vague, fatal to men,
Well needs it we should cram our ears with wool
And so pace by."

These expressions are not prompted by any sympathy with materialism. I am well aware that humanity fed upon such meat will never be great. But must we look back over two thousand years to find ideals—even in the matter of history writing? It will be a sad day, if it ever come, when the teaching of Greek and Latin shall fail in our universities and men shall cease to study them; but it is certainly unnecessary that the classical measuring rod shall be laid to all the dimensions of modern thought. Shall we not be free? Shall there never be a literary mortmain to lift the dead hand of the classics and leave us at liberty to render service where it is due?

Wherein lies the hitherto unequaled excellence of Thucydides and Tacitus? Not in their superior 'accuracy, love of truth and impartiality'; for 'Gibbon and Gardiner among the moderns possess equally the same qualities.' Mr. Rhodes would doubtless deprecate any suggestion of placing his own name in this honorable company, but I believe it would occur at once to those who are familiar with his works. Certainly it is not difficult for the unprejudiced reader to see in him a conscientious and brave fidelity to the truth that can be found in a higher degree in no historian, ancient or modern.

Nor does the advantage of the classical historians lie "in the collection of materials, in criticism and detailed analysis, in the study of cause and effect,

in applying the principle of growth, of evolution," in all of which 'we certainly surpass the ancients.' This with characteristic fairness Mr. Rhodes admits, but it is still his conviction that we have not risen to the classical standard of historiography.

Where, then, is the advantage in favor of Thucydides and Tacitus? The answer of their advocate is that they "are superior to the historians who have written in our century, because, by long reflection and studious method, they have better digested their materials and compressed their narrative. Unity in narration has been adhered to more rigidly. They stick closer to their subject. They are not allured into the fascinating by-paths of narration, which are so tempting to men who have accumulated a mass of facts, incidents and opinions."

Lest this discussion should resolve itself into an unprofitable difference about words, it may be worth while to consider just at this point the meaning of 'better history,' as Mr. Rhodes uses the term. He can hardly mean better from the scientific standpoint; for he admits that our historical science is superior to the ancient. If, therefore, we put that into the history we write, we shall make it better in so far at least. No doubt he means better from the standpoint of historiographic art.

Here lies, I take it, the *crux* of the controversy. Here begins the divergence between the scientific and the literary historians. They differ as to the relative values of the elements they represent, and this difference rests upon another still more fundamental as to the relative values of ancient and modern thought. This will serve to explain the objections I have already made to the attitude of Mr. Rhodes. I would not deny the justice nor the propriety of judging any historical work from the artistic standpoint. It would not be going too far to say that no history which fails when brought to such a test can be called good. But there is no art that can neglect its fundamental science. Other things being equal, that is the best history—even from the artistic point of view—which gives the clearest explanation of the unfolding of national life; and in this respect modern historiography is beyond all comparison superior to ancient. It is, therefore, not conclusive of the preeminent excellence of Thucydides and Tacitus to show the admirable proportion and conciseness of their narratives. If the historians of the present century show some loss in this respect, they do more than make it up by gain in others. It is not enough that the ancient writers of history told so well what they saw and understood; there was so much that they did not see and understand. If historical literature is to be distinguished from other forms and have canons peculiar to itself at all, its expository completeness must be considered in estimating it as good or bad.

It must be confessed, however, that the indictment of Mr. Rhodes against modern historians for prolixity is well-deserved. It could be sustained not only against the historians, but against nearly all book-makers of our time, and is far graver than his degree of emphasis would indicate. Life is short, and there is continually more to be crowded into it. The literature of almost every field of progressive thought is outgrowing the capacity of its workers, who are striving in truly reckless fashion to add thereto each what he can. Conciseness and proportion are, if not the most priceless jewels of all literature, at least their most useful and attractive setting. Blessed is he, and a benefactor of his race, who can deliver his message in few words, and for the rest keep silent.

One other point made by Mr. Rhodes deserves attention, namely, the advantage of writing contemporaneous history. Three difficulties lie in the way of it: First, that of getting the perspective; second, that of so far removing one's prejudices as to see the truth; third, that of telling the truth as seen, in spite of popular prejudice. If they can be overcome, the history of any epoch can be written best by those belonging to it. Mr. Rhodes has himself

shown how this can be done. But I do not think that he has established the superiority of Thucydides and Tacitus over modern historians. Their work may excel in conciseness and proportion, but that of the moderns has a more than compensatory advantage in deeper insight and clearer exposition. Partisans of either may fail to see that the shield is silver on one side and gold on the other; or, seeing this, they may fail to agree as to which is the golden side. "Let every man be fully persuaded in his own mind."

GEORGE P. GARRISON.
University of Texas.

THE RETARDATION OF SCIENCE.

WE hear a good deal about the advancement of science. There are huge associations which make it the object of their existence; there are universities, colleges, societies, museums, institutes and laboratories which reckon this as at least one of their aims; and the individual scientific workers, even those who look upon science as

> "The milch-cow of the field,
> Their only care to calculate how much
> butter she will yield"—

Even they, we say, profess to regard science as 'the goddess great,' and base their claim to honor on the service they have rendered to her. And, at this turning year of time, as we indulge in self-complaisant retrospect, we boast that, as a result of all this, science really has advanced. Contradictions, inconsistencies, harkings back: these we frankly admit; but the shattered theories line an onward path, and the discovered errors are lamps on the way of truth. We do well to rejoice; but we shall not do ill to look also at the other side of the shield. Might we not be advancing more rapidly, surely and easily? Are there not opposing forces which combine to effect the retardation of science?

Space need not be occupied by insisting on the inertia of governments, composed of ministerialists rather than statesmen on the lethargy and ignorance of the mass of people; on the curse of Babel, or on any such obvious hindrances to progress. But every scientific student knows that many of the difficulties in his way have no necessity in the nature of things, and that many of them are raised by scientific men themselves. We expect to meet with difficulties when we read a foreign language, but we resent having to ferret out an author's meaning when he publishes in our own tongue. This is what one has to do too often, for a vast number, if not the majority, of scientific men write abominably. It is all very well for the chemist in a factory, or the electrician to a lighting company, to be careless about the parts of speech; it hurts no one except himself and his employer. But for the student who makes researches in pure science, the case is altered. The object of the former is to earn his daily bread, and the sooner the better; the object—professed, at least—of the latter is to enlighten the world. A man may be a profound investigator, and may penetrate far into the mystery of the unknown, but if he cannot give an intelligible report to his colleagues, his travels in the undiscovered country will be disregarded. Worse than this, his fellow-workers waste valuable time in trying to read his riddles or very likely are led astray by his bungling presentation of veritable facts, and so science is retarded.

We do not propose to arouse the anger of our scientific friends by quoting elegant extracts from their writings to support our contention. We pass over the phraseology, to consider the general plan and the details of the arrangement. There are, it is true, masters in science who are also masters of method. But they have gained their mastery of the latter, as of the former, in the school of experience. This would be all very well were it not that we others have to suffer during their apprenticeship. Their immature essays, with all the faults of a beginner, have

to be read and reckoned with, and are just as much part of the self-styled literature of science as are their *magna opera*. This would not be worth a complaint were it inevitable; but that is just what it is not. If only scientific people in general could be got to care a little about these things, and if only their opinion could be organized and brought to bear more directly on the evil-doers, improvement would soon follow. The fact is that we are too content to muddle along, and what is everybody's business is nobody's business. Hence the student fresh from college, or while still a pupil, is set to attack some problem in science, which, with the help of his professor, he solves in a satisfactory manner. Then he must print, and here, too often, the help of the professor seems to be lacking. The student has had next to no training in the composition of scientific articles and none in the preparation of work for the press. He does not know how to find the previous literature, and when found he does not know how to quote it. Having no experience in the use of other men's writings, he does not know what to insert, what to omit, or what faults to avoid. He is, perhaps, a good draughtsman, but his media have been pencil and paint, and he has no idea how to do black-and-white work for the photo-engraver. He begins with a title in the style of the eighteenth century, that takes up three lines and leaves you in the dark as to the contents of his paper. Full of enthusiasm and imbibed knowledge, he either plunges into his subject without explaining what his subject is, or else he introduces it by a lengthy 'history,' mostly copied from the last worker that preceded him. He ends with a nicely-rounded period, but you search in vain for a summary of his results.

One cannot be hard on the poor young fellow, who doubtless will do well enough in time; but one can protest against the nonchalance that permits this state of things. There are two sources from which a remedy may spring, and to each we herewith make appeal. First, let the colleges provide instruction in the technique of authorship, just as they provide it in the technique of research. This will not help to swell the flood of publication, too great already; rather it will diminish it, by entailing more rigorous preparation on would-be authors. Let the student be taught the conventional rules that govern the formal aspect of his science, just as he is taught the laws of chemical combination or dental formulæ. In zoology and botany, for instance, he should be taught the rules of nomenclature, or at least those generally followed, and taught how to write the names of animals and plants in the accepted manner. He should be made to study the classical memoirs of great masters from the point of view of presentation—of manner rather than of matter. And even then he should not be turned loose on an unwilling public, but should be practised in writing and drawing for the press, in proof-correcting and so forth. The examiners of doctoral theses should consider their style and arrangement no less than their contents, and, if necessary, should insist on formal alterations being made before they give permission to publish.

So much for the universities. The second source of help lies in the editors, whether of independent periodicals or of publishing societies. The editor has, by tacit agreement, great powers. But in the case of publications devoted to pure science, those powers often seem to be very little used. There is a prejudice against interfering with an author's statement of his case; for here the substance is regarded as everything and the form as nothing, and an editor fears lest, in re-shaping the form, he may hack away an essential portion of the substance. This delicacy is likely to be more appreciated by the author in question than by his readers. The editors of purely scientific publications labor, of course, under a peculiar disadvantage in that both the contribution and the publication of matter are voluntary of-

fices with no binding contract; the editor is often only too glad to get 'copy,' and dare not risk offending a contributor. But the experience of many years in the conduct of many classes of publications has led us to the conviction that the authors most likely to be offended by judicious editing are those whose services can best be spared. Many, and especially beginners, often express their gratitude for editorial advice, and in most cases an editor has only to act *suaviter in modo* to be able to proceed *fortiter in re*. Moreover, in the case of the more serious and technical papers, these positions of author and editor are often reversed, since it is not so easy for an author to get his memoir published, especially with the requisite illustrations. Here, then, the editor has the whip hand, and his power is enhanced if he be acting for a learned society of which the author is a member. In brief, editors, as a rule, have the power, and we beg them to use it. Not every author can have a university training, but all (except the few rich and foolish enough to publish for themselves) must submit their manuscripts to the blue pencil of an editor. We want to see that blue pencil used.

But this leads us to another unfortunate influence tending to retard science, and that is the ignorance and incompetence of editors. We speak as one of the fraternity. How can an editor know the conventions of physicists, of zoologists, of botanists, of chemists, of geologists and all the rest? Specialization has proceeded so far that the editor of a general scientific journal nowadays must have, some may think, either enormous learning or vast audacity. But this is not quite a fair view of the case. Most scientific journals of any importance are, like other journals, run by a large staff of specialists in cooperation with one managing editor. Theoretically, at least, this is the case, as may be seen by reference to the covers of the 'American Journal of Science,' the 'American Naturalist,' 'Science,' and many more. If all these associate editors could be got to do editorial work, the supposed difficulty would vanish. Sorrowfully we admit that even editors do not always act rightly, and that 'Editor, edit thyself!' may be a true reproach. But the realization of a defect goes half-way towards curing it.

To put in few words what we have tried to make clear in these notes: Among the causes tending to retard science is carelessness as regards form and expression. The prevalence of this carelessness is largely due to want of training, and this defect can be remedied. We appeal, therefore, to teaching bodies to insist on instruction in the methods of scientific authorship; and we appeal to editors to exercise their powers in all questions of grammar, lucidity, arrangement and the formal conventions of each science.

AN EDITOR.

SCIENTIFIC LITERATURE.

CHRISTMAS ISLAND.

THOSE areas of the earth's surface outside of the Polar regions which retain their original fauna and flora unmodified by the action of man and the organisms which accompany him in his migrations are very few and are rapidly passing away. It is obvious that it is of great importance that we should know something of the conditions, animals and plants which exist under such circumstances, in order that the effects of the influx of human beings into a virgin wilderness may be determined and recorded.

Opportunities for such researches are very rare and in a few years will be non-existent. A settlement has recently been made upon the isolated bit of land known as Christmas Island, which lies some two hundred miles southwest of the western part of Java and is separated from it by sea which reaches a depth of three thousand fathoms. At the initiative and expense of Sir John Murray, known from his connection with the Challenger expedition, Mr. C. W. Andrews, of the British Museum, was granted leave of absence for the purpose of making a thorough biological survey of this island, and the report which is the result of his observations and collections, assisted by a number of expert naturalists in working up the material, has just been issued by the Museum. It is believed to be the most elaborate account of the animal and plant life of an oceanic island ever published.

The island is of volcanic origin and comprises, beside igneous rocks, a variety of tertiary and recent limestones. Most of the life upon it is of the Malaysian type, the prevalent winds being from that quarter. However, there is a recognizable portion of it which is related to that of Ceylon and another to that of Australia, though the latter country is nine hundred miles away. About ten per cent. of the plants and forty-five per cent. of the three hundred and nineteen species of animal organisms are regarded as peculiar to the island. There are thirty-one species of birds, five of mammals and six of reptiles, of which sixteen are known only from this island. These figures, of course, exclude all pelagic forms. Altogether, many interesting facts have been brought out and several puzzling questions raised in the discussion of the data which form the basis of this valuable report.

PALEONTOLOGY.

THE absence of a text-book on paleontology in English which in any adequate measure reflected the philosophic illumination of modern zoology has long been a subject of regret. The only manual worthy of the name which has enjoyed any wide reputation among scientific paleontologists has been that of von Zittel, published originally in German, but since well rendered into French with some additions. Dr. C. R. Eastman, of Harvard University, having in view a translation of von Zittel's 'Grundzüge,' with the permission of the author, submitted the different sections of the work to various American specialists for revision. The original work was lavishly illustrated with excellent, mostly original figures, which have been utilized in the present translation. The task of revision was undertaken by a number of experts as a labor of love, in the desire that the deficiency in our text-book literature, above referred to, might be done away with and that English-speaking students might possess a work of reference in which modern ideas

of classification and of the relations and development of organic life on the globe would find a place. This task presented many difficulties, both for the revisers and for the editor, and one can not but regret that the cost of illustration and the difficulties of finding a publisher for a wholly new work stood in the way of preparing a manual which should be avowedly, as well as practically, independent. The excellent work of von Zittel, good as it is, was designed on the lines of the science as it was a quarter of a century ago. The revision, though in several departments fundamental, is naturally more or less uneven, the restrictions of space insisted on by the publishers and other causes hampering the freedom of treatment desirable, while the composite nature of the work, part of which was stereotyped before other portions were received in manuscript, has inevitably resulted in some incongruities. However, in spite of such minor deficiencies, the result has been the most notable advance in the treatment of invertebrate paleontology as a whole since text-books began to be made. This is especially evident in such groups as the Polyzoa, Mollusca, Brachiopods and Trilobites, in which the illustrations and a part of the bibliography are all that remain of the older work. Any work in which the latest views of large divisions of the animal kingdom are summed up by such experts as Wachsmuth, Ulrich, Schuchert, Hyatt and Beecher must appeal strongly to students and long remain an indispensable aid to science, whether all matters of detail meet with final acceptance or not. Wholesale changes, such as are indicated in several of the groups, might very well be unacceptable to the original author of the work thus modified, but, while suspending his opinion on the advisability of some of the novel methods, Dr. von Zittel, in his preface to the present work, has been moved by the true scientific spirit which, while holding fast to that believed to be good, is ever ready to welcome any new light. The untouched riches of American fossiliferous horizons, especially above the Paleozoic, are almost incalculable, and the existence of Dr. Eastman's valuable text-book can not but be a most important factor in the training of those who will hereafter bring to light the riches now awaiting the advent of paleontological explorers.

ZOOLOGY.

THERE has been somewhat of a dearth of works on natural history during the past few months. Among those which have appeared is 'Nature's Calendar,' by Ernest Ingersoll, a book intended to stimulate the reader's power of observation by inducing him to note down, day by day, what he sees going on in the world of animals and plants about him. There are twelve chapters, one for each month, in which the author writes pleasantly of what is being done by the more familiar beasts and birds, reptiles, fishes and insects, as well as plants, in an ordinary season in the vicinity of New York. The limits, however, have not been very rigidly drawn, and we read of deer, bears and wildcats, animals not commonly found about that city. We are told, as the case may be, how animals and plants are guarded against extremes of heat and cold, at what time the animals make their appearance, when the woodchuck comes from his burrow and the shad and herring ascend the streams; when they mate; at what time the eggs are deposited or the young come forth; at what time the buds burst and the blossoms open, and of many other occurrences. Each chapter is preceded by a full-page plate, after photographs by Clarence Lown, of some landscape in accord with the text, and at the end of each chapter is a 'calendar,' in which the birds naturally appear in the majority, stating what animals are present, the approximate times at which, if they migrate, they come or go, or the dates on which they go into or come out of winter quarters. The compact text oc-

cupies less than half the page, the remainder being left for recording the observations of the reader, who thus becomes a joint author and has the pleasure of seeing whether or not he is in agreement with his collaborateur.

The book is written in a pleasing style and while here and there a little loose in its statements, one should not hold the author too strictly to account, since the very object of the book is to induce the reader to make his own observations and draw his own deductions, and the possibility of proving someone wrong is a great stimulus towards this end.

THE recent issue of part four, consisting of 283 pages of text and 392 plates, completes Jordan and Evermann's 'Fishes of North and Middle America,' published as Bulletin No. 47 of the U. S. National Museum. The 'Synopsis of the Fishes of North America,' by Jordan and Gilbert, issued in 1882, was a single volume of 1,074 pages, with no plates, containing descriptions of 1,340 species of fishes; the present work is in four volumes, consisting of 3,528 pages, 240 of which are devoted to the index and 392 plates, and over 3,000 species are described. Naturally, a considerable portion of this increase is due to the extension of the area covered, but still a large part is caused by the increased number of species now known to ichthyologists. The work is in no sense of a popular nature and it goes without saying that it is simply indispensable to the student of North American ichthyology; it will doubtless be many years before any revision of it is attempted. It is not our purpose to review the work—to do that would require much knowledge and much time—but to congratulate the authors on the completion of their task.

SIX years ago Mr. Robert Ridgway, at the request of Dr. Goode, undertook the preparation of a work that should do for birds what Jordan and Evermann have done for fishes, give a description of all forms inhabiting North America north of the Isthmus of Panama, including as well the West Indies, the Galapagos and the islands of the Caribbean Sea. Although several times interrupted by the illness of Mr. Ridgway, the manuscript of the first volume is now ready for the printer and the second is so far advanced that it will probably be completed by the end of the year. The outlines for the entire series, which will, it is estimated, fill seven octavo volumes of 600 pages each, are drawn up, and several of the other volumes are well under way.

The total number of species and subspecies to be treated is, roundly speaking, 3,000, and the first volume, devoted to the *Fringillidae*, comprises descriptions of over 370 species and subspecies. There are keys to the families, genera and species, and besides a careful technical description and very full synonymy, the range of each species is given; all extra-limital families are included in the keys, but extra-limital genera and species only when their number is small. As much more work has been done in ornithology than in ichthyology, the synonymy will be much more extensive than in Jordan and Evermann's 'Fishes of North and Middle America,' and as particular attention has been given to the verification of references and ascertaining the original spelling of generic and specific names, this part of the work has necessitated an amount of labor that can only be appreciated by those who have been engaged in similar tasks. In addition, the type locality of each species and the present location of each type has been given whenever it could be ascertained.

The work is based on the collections of the U. S. National Museum, but much material has been examined belonging not only to other museums, but to private individuals who have generously placed their specimens at Mr. Ridgway's disposal. The collections of the Biological Survey of the Depart-

ment of Agriculture have been particularly helpful in the case of Mexican species.

AGRICULTURE.

'THE USE OF WATER IN IRRIGATION' is the title of an extensive bulletin just issued by the U. S. Department of Agriculture, under the authorship of Prof. Elwood Mead, expert in charge of irrigation investigations, and C. T. Johnston, assistant. It embodies the results of extensive investigations conducted last year with the assistance of a number of collaborators in ten States of the arid region and presents an array of data on the use which is being made of water under different systems of management, such as has never before been collected for the irrigated region of this country. It constitutes a part of the irrigation studies which are being carried on under the U. S. Department of Agriculture.

To many readers the lavish prodigality which has characterized the diversion and application of water for irrigating will come as something of a surprise, when the paramount importance of water in developing the arid country is considered. This has been fostered by the fact that "the laws which govern appropriations of water from streams have, in most cases, no relation to the actual practice of irrigation and therefore fail to secure either the systematic distribution or best use of the available supply." Ditches diverted more water than was used; their owners claimed more than they could divert, while decrees gave appropriators titles to more water than the ditches could carry and many times what the highest floods could supply. Little was known as to the quantity of water needed to irrigate an acre of land, and in the absence of such information the ignorance and greed of the speculative appropriator had its opportunity.

In the investigations reported, farmers whose fields were under observation were instructed to use water as they had hitherto been in the habit of doing. The result of the measurements of the water used showed very forcibly the influence of waste in lowering the 'duty of water' and of care and skill in increasing it. They confirm the conviction long held by students of the subject that the amount of water used in practice bears no definite relation to the requirements of the crop, but is subject to the whim of the individual and the supply of water provided by the contract with the canal company. For instance, the average amounts of water used in different part of New Mexico varied from less than three feet to nearly seven feet. This was independent of the rainfall. In many cases the farmers using the least water got quite as good crops as those who used enormous quantities. On some soils which were not well drained there was a very marked injury from excessive irrigation. In the Boise Valley in Idaho it was found by measurement that fully one-half the water now diverted by canals is wasted under present methods. Apart from the losses from extravagant use of water, there are heavy losses, under present management, from evaporation and seepage from the canals. The average of the measurements made show the loss from this source to be fully thirty per cent. Mr. Mead expresses the conviction that throughout the sections where measurements were made last year it will be possible, through improved methods, to double the average duty of water now obtained, so that the quantity now required for one acre will serve to irrigate two.

The importance of this becomes more strikingly apparent when it is remembered that there is a limit to the amount of land which can be reclaimed with the available water supply, generally estimated at about seventy million acres, or approximately one-fifth of the arid region, and that the thousands of miles of canals and laterals thus far constructed have only reclaimed an area approximately as great as the State of New York.

The results reported in this bulletin

not only furnish the basis for improving the existing methods of irrigation and for framing more equitable laws, but they indicate the lines along which investigation should be directed.

THIS year marks the twenty-fifth anniversary of the establishment of agricultural experiment stations in the United States. Beginning with a single station in Connecticut in 1875, the number has steadily grown until to-day we have a system of experiment stations embracing every State and Territory in the Union. The history of this movement and the present status of the stations is the subject of an interesting and attractive volume of over six hundred pages, prepared by Dr. A. C. True, director of the Office of Experiment Stations, and Mr. V. A. Clark, assistant, and published by the United States Department of Agriculture. It is a comprehensive account of the evolution and development of the experiment station enterprise; the organization, lines of work and equipment of the stations; some of the more striking results of practical application which they have attained; and a description of each of the fifty-six stations individually. These latter descriptions are illustrated by one hundred and fifty-three plates, showing the buildings, fields, laboratories, herds, etc., of the different stations. The greatest impulse to the station movement was given by the passage of the Hatch Act, in 1887, providing for the establishment of experiment stations in connection with the land-grant colleges, and appropriating $15,000 a year to each State and Territory for their maintenance. At that time there were some twelve stations, a part of which received regular State appropriations. During 1888 stations sprang into existence rapidly all over the country, and in a surprisingly short time these stations had justified the expectations of their advocates and proved their usefulness to the agriculture of the country.

During the past ten years more than ten million dollars have been expended in their maintenance, seven million of which has come from the Federal Government. Dr. True reviews the manifold benefits which have come from their operations, and points out their value in (1) the introduction of new agricultural methods, crops or industries, and the development of those already existing; (2) the removal of obstacles to agriculture, such as diseases of plants and animals, injurious insects and other natural enemies; (3) the defense of the farmer against fraud in the purchase of fertilizers, feeding stuffs, insecticides and in other ways; (4) aiding in the passage and administration of laws for the benefit of agriculture; and (5) in an educational way. Brief as this summary necessarily is, it brings out very forcibly the wide range of usefulness of the experiment stations to the farming community, touching nearly every phase of agricultural operation, and their very potent influence in arousing widespread interest in the various forms of agricultural education. "The stations are not only giving the farmer much information which will enable him to improve his practice of agriculture, but they are also leading him to a more intelligent conception of the problem with which he has to deal, and of the methods he must pursue to successfully perform his share of the work of the community and hold his rightful place in the commonwealth." One large result of the educational work of the stations has been the general breaking down of the popular conception that agriculture is not capable of improvement through systematic and progressive researches in its behalf conducted on scientific principles. "There is now in this country a much keener appreciation than heretofore of the fact that the problems of agriculture furnish adequate opportunity for the exercise of the most thorough scientific attainments and the highest ability to penetrate the mysteries of nature."

Considered merely as organizations for the advancement and diffusion of knowledge, the stations have attained

to an important position. They now include upon their staffs nearly seven hundred persons, who constitute a body of organized scientific workers such as is hardly to be found in any other field of investigation. While they are laboring primarily for the advancement of applied science, they have made a quite large number of important contributions to the sciences, and their investigations are followed with interest by workers in similar lines the world over.

The past history of the stations gives every assurance of increasing strength and efficiency in the future. They have passed through the formative period of their existence, and year by year have secured a better equipment and more thoroughly trained officers. "The people generally have come to regard the stations as permanent institutions, and are convinced of the usefulness of their work. They will, therefore, enter upon the twentieth century with bright prospects for the development of their researches in scientific thoroughness and accuracy and for the securing of larger practical results."

THE lastest addition to the list of experiment stations is the Alaska Station, which was established last year, with headquarters at Sitka. Some preliminary work to determine the practicability of conducting station work there was carried on the year previous. The report of the operations of the Alaska Station for 1899 has recently been issued by the United States Department of Agriculture.

It is only recently that Alaska has been regarded as possessing agricultural possibilities. Potatoes and a few other vegetables were grown in a small way by some of the settlers and at a few missions, but for more than a quarter of a century after Alaska became a part of the United States no effort was made to encourage agriculture. It was not until the discovery of gold in Alaska attracted a large number of people there and created a demand for foodstuffs that any interest was manifested in the study of its agricultural capabilities, or in the attempt to establish there at least sufficient agriculture to meet a considerable proportion of the needs of its population. The results of the experiments carried on by the Alaska Station have been a surprise to those who have regarded the country as suited only to the fisheries, the fur trade and mining. Professor Georgeson's report shows that vegetable growing in Alaska is no longer a matter of experiment. "It has been abundantly proved that all the common, hardy vegetables which are grown in the gardens of the States, such as potatoes, cabbage, cauliflower, kale, peas, onions, carrots, parsnips, parsley, lettuce, celery, radishes, turnips, beets and the like, in their numerous varieties, can be grown in Alaska to a high degree of perfection and attain a crispness and delicacy of flavor which is rarely equaled in the best farming regions of the States, because they are there very frequently dwarfed and toughened by drought and heat." He has also shown that in Southeastern Alaska and in Cook Inlet oats, barley, buckwheat and spring wheat will mature with careful culture. Flax has been grown for two years with marked success, indicating that the climate is particularly favorable for flax growing. In addition to the native grasses, which grow luxuriantly, a long list of forage plants have been successfully grown, and Professor Georgeson asserts that it is safe to depend on growing an abundance of feed for live stock every year, which leads him to believe that dairying, beef, mutton and wool production are assured of success. Thus far the experiments have been confined to the southern coast of Alaska, but the present season work will be undertaken in the Yukon district and at other places in the interior.

PHILOSOPHY.

THE appearance of a book by the veteran Dr. Hutchinson Sterling, from whose 'Secret of Hegel,' published in 1865, the rise of the neo-rationalist

school in Britain and the United States dates, is always welcome. And, even if scientific students lay up old scores against him for his attack on Huxley, and for his more recent, suggestive, though unfair assault on the Darwinians, they must remember that he represents one type of contemporary thinking favored by a large and influential group; they must remember, too, that he was trained as a physician and has competent first-hand knowledge of the scientific standpoint. The present work—'What *Is* Thought,' published by the Blacks in Edinburgh, and imported by the Scribners—although highly metaphysical, in the Hegelian sense, contains not a little interesting material. The early chapters, on 'Substance,' the 'Ontological Proof,' 'Self-consciousness,' and the like, summarize views familiar to philosophical students, and known more or less to scientific men through such books as Prof. Ritchie's 'Darwin and Hegel,' and Prof. Watson's 'Kant and his English Critics.' Fortunately, these chapters occupy but a third of the volume. The three hundred pages devoted to some account of the development from Kant, through Fichte and Schelling, to Hegel, are more important, and present, in some aspects, the best statement of the subject at present available in English. The long chapter on Kant is full of points demanding consideration from thoughtful scientific workers; while the estimate of the relations between Schelling and Hegel must be held of exceptional value. No doubt, the book is hard reading; all Dr. Sterling's works are, for he has never been able to rid himself of the curious Carlylese style that so strongly marked his first, and greatest, effort. Nevertheless, all the old vigor and all the power remain. It may be added that the book appeals very specially to students of the history of European thought in the nineteenth century—a subject which, particularly as concerns the relation between the sciences and philosophy, is very far from being understood as yet.

It is not easy to speak of the English translation from the German version of the Danish original of Höffding's 'History of Philosophy.' Professor Höffding's work is admirable, as all know; the translation—well, the less said of it, the better. We dismiss it with but one comment. The most laughable of the translator's numerous errors happens to be venial, as too many others are not. He tells us that Geulincx died at Pesth. Knowing of the Dutch philosopher's sojourn in Lyons, but being in ignorance of a visit to Pesth, one naturally turned to the original, and found Höffding recording that Geulincx died of the plague (*pest*)! This is fit companion for the similar error (now classical) whereby the Wolffian psychology (*wolffischen Psychologie*) was Englished as *animal* psychology. *Pest* and Pesth obviously bear much the same relation to each other as Wolff and wolf! This may be sublime, it is hardly translation. One may venture to express a hope that the publishers will see to a thorough revision by a competent hand. The work is far too important to be left thus; moreover, we are unaccustomed to associate such a performance with the house of Macmillan. As compared with other histories of philosophy, Höffding's possesses quite peculiar attractions for those whose main interests lie in the direction of science. The space at disposal compels the briefest statement of these points. In the first place, then, Höffding devotes great attention to the formation and import of the Renaissance view of the universe. He bears it specially in mind that this view was evolved as much, if not more, by science than by philosophy. Consequently, Copernicus, Galileo and Newton take their places alongside Descartes, Spinoza and Leibnitz. The importance of this method of treatment can hardly be exaggerated to-day. For one of the main problems at the moment is nothing more than a determination of the extent to which 'modern thought' is still controlled by

the cosmic conceptions and categories of the sixteenth, seventeenth and eighteenth centuries. In the same way generous consideration is accorded to thinkers who are passed over with scant ceremony in the ordinary text-books. Bruno, Bacon and Kepler are instances of this. The same appreciation of the immense importance of science for philosophical inquiry marks the perspective in which nineteenth century workers are placed. Kant, who is more influential for science than any other thinker, receives very full discussion—a discussion, too, which however one may dissent from it, as the present writer dissents, bears everywhere the traits of prolonged study and of first-hand acquaintance with the principal primary sources. Similarly, the English school of Positivists, elbowed out in the country of its birth as it has been by a metaphysicising Hegelianism, is restored to its true importance, and the post-Kantian rationalism, that has ousted it, is bidden come down lower. In a work so extensive there are, of course, many points on which one can not agree with the distinguished author. For example, his conception of the relation between Descartes and Spinoza requires revision; he makes too much of Bruno; he has not reasoned the standpoint of Copernicus out to its logical conclusion; Hobbes and Rousseau get more than their due, and Hume less; the peculiar genius of the English school, particularly as represented by Locke, does not seem to have been caught. But, after all, these are defects which appear to the expert and do not seriously mar the book as a whole., For the scientific man, it is the best presentation of the constructive development of philosophical theory from the Renaissance till within the last twenty-five years.

THE PROGRESS OF SCIENCE.

IT is frequently said that the days of the discovery of general principles and far-reaching laws are past, and that students of science are now settling down to minor questions and the elaboration of details. The amount of specialized work, unproductive of immediate result in general truths, is naturally increasing, both because of the assiduity of scientific workers and because each general truth brings a number of minor problems. But the acquisition of wide theories is by no means at an end when we are told, as we have been during the last year, that the nebular hypothesis of Laplace is at variance with the facts; that the atoms are made up of smaller bodies whose nature can be known; that inertia and gravitation are not special facts by themselves, but are the results of the electrical charges of bodies. In papers in the *Journal of Geology* and the *Astrophysical Journal*, Prof. T. C. Chamberlin and Dr. F. R. Moulton seek to show that the nature of the earth's atmosphere is not compatible with the traditional idea of the formation of the earth from a hot gaseous ring; that the force of gravity would not cause such a ring to form a sphere; that the matter given off by a rotating spheroid of gas would not go off in the form of rings, and that the present mechanical arrangement of the solar system could not be derived from a spheroidal nebula such as Laplace assumed. It is suggested that the spiral nebulæ may offer conditions analogous to those of our own solar system in its early stages. The hypothesis receives confirmation from the important paper published just before his death by Keeler, and described by Professor Campbell in the obituary notice published above. Keeler's beautiful photographs with the Crossley reflector, several of which are reproduced by Professor Newcomb in the opening article of this issue of the MONTHLY, indicate that most nebulæ are in fact spiral.

RECENT researches in molecular physics threaten to disqualify the time-honored position of the atoms as the smallest known particles of matter and to push the analysis of material substances to a point where the dreams of a primary order of sub-atoms or corpuscles whose varying combinations shall account for the so-called 'elements' seems almost probable. The work of Prof. J. J. Thomson and others on the electrical condition of gases has resulted in the hypothesis that the ions or bodies carrying the electric charges are not greater than one-thousandth the mass of the hydrogen atom; further, that the mass of each ion is the same in the case of all the gases tried, regardless of their atomic weights. The latter statement indicates that atoms of totally different constitution yet consist of corpuscles that are alike at least in mass. Although the experiments and reasoning which have led to these conclusions are beyond the comprehension of any but the specialist, and so cannot be suitably given in this connection, it should be remembered that the conclusions are far from being mere speculations. On the contrary, they are the result of the most careful experimental work, accord well with a number of facts and have already been tentatively applied to the explanation of other phenomena. Thus, Dr. Reginald A. Fessenden has arrived at certain far-reaching hypotheses concerning the possible explanation of inertia and gravitation in terms of electric charges. In a recent issue of *Science* he writes: "We thus find that both inertia and gravita-

tion are electrical effects and due to the fact that the atom consists of corpuscular charges. The constant ratio between quantity of inertia and quantity of gravitation, for a given body, is thus explained. We may state the theory thus: The inertia of matter is due to the electromagnetic inductance of the corpuscular charges, and gravitation is due to the change of density of the ether surrounding the corpuscles, this change of density being a secondary effect arising from the electrostatic stress of the corpuscular charges."

WE are able to publish in the present issue of this JOURNAL an article on China, by Mr. William Barclay Parsons, which represents the best knowledge obtainable from recent and accurate observations. The present political crisis has called forth other articles, and books will be forthcoming, giving a certain amount of reliable information in regard to the physical and social aspects of the country. Still, the difference between Eastern and Western civilization becomes apparent the moment any definite question is asked about the natural resources or social conditions of China. Almost any fair question of this nature about our own country would meet with a ready and reasonably complete answer from some one of the government bureaus or from general scientific literature. When it is asked about China we obtain in general only opinions of travelers, missionaries or other foreign residents, opinions based on vague data and guided usually by mediocre scientific training. On what is perhaps the most important questions of all: What is the mental and moral make-up of the Chinese people? How will they act singly or collectively under given conditions? we get even less accurate judgments than we do on the mineral resources, the fauna and flora, etc. It is a pity that the sciences of human nature are not far enough advanced to make it practicable to send a body of anthropologists and psychologists to China to examine and diagnose the mental capacities and proclivities of the race. Even as things are, such a report would be worth something as a supplement to the impressions of those who have written about China. It might be assumed from the general principles of the theory of evolution that races which have for many centuries been subject to a nearly constant environment will be greatly disturbed by new conditions. It is not surprising that the native tribes of America and Australasia should be exterminated. On the other hand, rabbits imported into Australia and negroes imported into America have flourished, and the Japanese have adapted themselves to a new civilization in a marvelous fashion. Common-sense and science are in equal measure unable to foretell what will happen to China and its peoples.

IT will be remembered that the late Dr. Alfred Nobel bequeathed nearly all his great fortune, estimated at ten million dollars, for the establishment of five prizes. The exact terms of his will, which have only recently been made public, are as follows:

The capital, converted into safe investments by the executors of my will, shall constitute a fund the interest of which shall be distributed annually as a reward to those who, in the course of the preceding year, shall have rendered the greatest services to humanity. The sum total shall be divided into five equal portions, assigned as follows:

1. To the person having made the most important discovery or invention in the department of physical science.

2. To the person having made the most important discovery or having produced the greatest improvement in chemistry.

3. To the author of the most important discovery in the department of physiology or of medicine.

4. To the author having produced the most notable literary work in the sense of idealism.

5. To the person having done the most, or the best, in the work of establishing the brotherhood of nations, for the suppression or the reduction of standing armies, as well as for the formation and propagation of peace conferences.

The prizes will be awarded as follows: For physical science and chemistry, by the Swedish Academy of Sciences; for works in physiology or medicine, by the Carolin Institute of Stockholm; for literature, by the Academy of Stockholm; finally for the work of peace, by a committee of five members, elected by the Norwegian Stortung. It is my expressed will that nationality shall not be considered, so that the prize may accrue to the most worthy, whether he be a Scandinavian or not.

The organization for executing this will has, after an interval of about three years, been completed, and its nature has been formally announced in an official communication to our government. Nobel's intentions have not been exactly carried out, the chief deviations being that part of the money is used for the establishment of certain Nobel institutes, the objects of which are not exactly defined. On these institutes and on the incidental expenses of awarding the prizes, one-fourth of the income may be expended. Further —and this seems to be in direct violation of the provisions of the will— prizes need be given only once in five years, and the money thus saved may be used to establish special funds 'to encourage otherwise than by prizes the tendencies aimed at by the donor.' It is to be hoped that the administrators will make only judicious use of these provisions, for Nobel's purpose to establish for eminence in science and literature a few rewards as munificent as the world gives in politics, war or business is too wise to be neglected. Any attempt to divert the funds to the encouragement of local institutions or to the education of inferior men should be carefully guarded against. Nobel's will explicitly ordered that the money be awarded in prizes for eminence and without any consideration of nationality.

NEW YORK UNIVERSITY received early in the year a gift of $100,000 from Miss Helen Gould for the erection of a Hall of Fame. On the colonnades are to be inscribed the names of the most eminent Americans, and thirty of these have recently been selected by the Senate of the University, in accordance with the votes of certain prominent men selected as judges. Ninety-seven of these handed in their votes, and the following eminent Americans received the majority required: George Washington 97, Abraham Lincoln 96, Daniel Webster 96, Benjamin Franklin 94, Ulysses S. Grant 92, John Marshall 91, Thomas Jefferson 90, Ralph Waldo Emerson 87, Robert Fulton 85, Henry W. Longfellow 85, Washington Irving 83, Jonathan Edwards 81, Samuel F. B. Morse 80, David Glasgow Farragut 79, Henry Clay 74, Nathaniel Hawthorne 73, George Peabody 72, Robert E. Lee 69, Peter Cooper 69, Eli Whitney 67, John James Audubon 67, Horace Mann 67, Henry Ward Beecher 66, James Kent 65, Joseph Story 64, John Adams 61, William Ellery Channing 58, Elias Howe 53, Gilbert Stuart 52, Asa Gray 51. It will be noticed that the list contains four inventors—Robert Fulton, S. F. B. Morse, Eli Whitney and Elias Howe—while there are but two scientific men—J. J. Audubon and Asa Gray, unless Benjamin Franklin be included. The judges probably were more interested in birds and flowers than in the history of science in America. Audubon and Gray should certainly be included in a list of eminent scientific men, but not to the exclusion of Benjamin Thompson (Count Rumford), Joseph Henry and others. Twenty further names are to be added in 1902 and thereafter five at intervals of five years.

THE papers and discussions before many of the congresses of the Paris Exposition were technical in character, as is demanded by the advanced and specialized state of the sciences, but there also met at Paris during August and September a number of congresses devoted to the mental and social sciences which perhaps presented more aspects of interest to those who are not special students. The only one of these congresses that can be noted

here is that devoted to psychology, a science intermediate, in its present state of development, between the exact sciences and those subjects in which individual opinions are more prominent than ascertained facts. About three hundred students of psychology attended the fourth international congress, which met in seven sections, namely: (1) Psychology in its relation to anatomy and physiology; (2) Introspective psychology in its relation to philosophy; (3) Experimental psychology and psychophysics; (4) Pathological psychology and psychiatry; (5) Psychology of hypnotism and related phenomena; (6) Social and criminal psychology, and (7) Comparative psychology and anthropology.

AMONG the subjects discussed by the Psychological Congress was the establishment at Paris of a 'Psychical Institute' under the auspices of an international society. This Institute proposes to do for 'psychics' what the Pasteur Institute does for biology and pathology. According to M. Janet, its aims are: (1) To collect in a library and museum all books, works, publications, apparatus, etc., relating to psychical science; (2) To place at the disposal of researchers, either as gifts or as loans, according to circumstances, such books and instruments necessary for their studies as the Institute may be able to acquire; (3) To supply assistance to any laboratory or to any investigators, working singly or unitedly, who can show that they require that assistance for a publication or for a research of recognized interest; (4) To encourage study and research with regard to such phenomena as may be considered of sufficient importance; (5) To organize lectures and courses of instruction upon the different branches of psychical science; (6) To organize, as far as means will allow, permanent laboratories and a clinic, where such researches as may be considered desirable will be pursued by certain of the members; (7) To publish the 'Annales de l'Institut Psychique International de Paris,' which will comprise a summary of the work in which members of the Institute have taken part and which may be of a character to contribute to the progress of the science. The Institute aims to cover the whole field of psychology, but it appears from the discussions and from those who are interested in the movement that it will favor those more or less occult phenomena which go under the name 'psychical.' Thus the American members of the committee are Prof. J. Mark Baldwin, Prof. J. H. Gore and Mr. Elmer Gates, which is as if the committee on a pathological institute consisted of one physician, a lawyer interested in homeopathy and a faith curist.

THE experiment demonstrating the relation of mosquitoes to malarial fever, undertaken under the auspices of the London School of Tropical Medicine, has apparently been successful. Its somewhat dramatic character and wide advertisement in the daily papers will prove of benefit both in leading people to take precautions to avoid infection by mosquitoes and in leading to increased appreciation of the importance of experiments in medicine. Drs. Sambon and Low, who have been living in a hut in one of the most malarial districts of Italy since last June, drinking the water, exposed to the night air and taking no quinine, have so far been entirely free from malaria. The converse of the experiment has been equally successful. Dr. Patrick Manson's son, who had never suffered from malaria, allowed himself to be bitten in London on three occasions by mosquitoes fed in Rome on patients suffering from malaria. He suffered an attack of fever and the tertian parasites were found in his blood. Americans, and especially readers of this journal, may be interested to learn that the earliest article on the relation of mosquitos to malaria was published in the POPULAR SCIENCE MONTHLY for September, 1883. Prof. A. F. King, still living in Washington, contributed an article entitled

'Insects and Disease—Malaria and Mosquitoes,' in which, after calling attention to the then recent researches of Dr. Patrick Manson, in China, and others, proving that the mosquito acts as an intermediary host of *Filaria sanguinas hominis*, he proceeds to point out in detail the connection existing between mosquitoes and malaria. Nineteen special arguments are marshaled, several of which deserve consideration at the present time. Among the points urged by Dr. King is the fact that malaria is prevented by mosquito nets, a statement being quoted to the effect that "on surrounding the head with a gauze veil or conopeum the action of malaria is prevented and that thus it is possible to sleep in the most pernicious parts of Italy without hazard of fever." This was, of course, written long before Laveran discovered *Plasmodium malariae*, and before exact experiment was possible, but Dr. King deserves much credit for bringing together so much evidence in favor of a theory the correctness of which could only be demonstrated twenty-seven years later.

THE proper standard for atomic weights has occasioned controversies among chemists for nearly a century, but at last bids fair to be settled, through the practical agreement of an international committee, under the auspices of the German Chemical Society. The original standard, proposed by Berzelius, was the weight of the oxygen atom taken as 100. This gave rise to very large numbers, in the case of numbers with high atomic weights, and gradually the use of hydrogen = 1 came to supersede that of oxygen = 100. So long as it was assumed that the oxygen atom was exactly sixteen times as heavy as the hydrogen atom, this standard was satisfactory. With increasing refinement of analytical work, it began to appear that the atomic weight of oxygen, with reference to hydrogen, was slightly less than sixteen. For some time the exact figure was supposed to be 15.96. This necessitated a recalculation of the atomic weights of all the elements, for they are for the most part determined with reference directly to oxygen or chlorin, and only indirectly with reference to hydrogen. As it was certain that the final word had not been said as to the atomic weight of oxygen, the suggestion was made by a few chemists to use as a standard *oxygen* = 16. The first article published advocating this new standard was by Dr. F. P. Venable, of the University of North Carolina, in 1888. Discussion was particularly aroused in the German Chemical Society by Professor Brauner, of Prague, who was strongly supported by Ostwald and opposed by Meyer and by Seubert. The latter, who is one of the great authorities on atomic weights, has since come to the support of *oxygen* = 16. The recent report of an international committee representing chemical societies of eleven countries (America, Belgium, Germany, England, Holland, Japan, Italy, Austria, Hungary, Sweden, Switzerland), showed forty in favor of *oxygen* = 16, seven opposed, while two wanted both standards. Except one American, none were opposed but Germans, and the German vote was a tie between the two standards. The objections raised against using *oxygen* = 16 as a standard seem to be solely from a didactic standpoint, in having something other than unity as a standard. It was clearly pointed out by Dr. Venable in his second paper that there was no necessary connection between the standard and unity. Some objectors would take oxygen as unity, but this would be impracticable, as it would make such radical changes in the numbers now in use. An additional reason for the newer standard is that a large proportion of those weights most frequently used approach very closely to whole numbers, a point of no slight advantage to the technical chemist. While the small minority of the international committee are making a vigorous protest against the decision of the majority, it seems probable that this decision will be concurred in by most chemists throughout the world.

FOREIGN men of science have a pleasant custom of celebrating the long service of their colleagues. Giovanni Virginio Schiaparelli was born in 1835, and in June, 1860, he was appointed one of the astronomers of the Observatory of Milan. In June, 1900, thirty-six Italian astronomers joined in a memorial to him which has been handsomely printed in a pamphlet of eighty-eight pages. On November 1 of this year Schiaparelli is to retire to private life, after more than forty years of active service. For thirty-eight years he has been director of the observatory at the Brera palace, which, by his researches, has been raised to a very high rank. His first observations were made with quite small instruments, but his successes with limited means finally brought splendid modern instruments to his observatory. His earliest examinations of planets (1861) were made with a small telescope of only four inches aperture. For many years he employed a telescope of eight inches, but since 1887 he has had at his disposition a refractor of eighteen inches —one of the powerful telescopes of the world.

Schiaparelli is best known to the world at large by his long continued and very successful observations of Mars. It is not too much to say that his work has revolutionized our notions of the physical conditions existing on that planet. It is more than likely that some of his conclusions will have to be revised; and it is certain that some of his less cautious followers have drawn conclusions that the master's observations do not warrant. However this may be, his own work has a high and permanent value. Astronomers rate other researches of Schiaparelli's quite as highly as his studies of the planets. The relation between comets and meteor-showers was most thoroughly worked out by him; we owe to him also thousands of accurate observations of double stars; as well as a great number of important researches on many and various questions of mathematics, physics and astronomy. It is interesting to note, here and there, in the list of the 206 memoirs which he has published, certain papers of an antiquarian and literary turn—on the labors of the ancients before Copernicus; Græco-Indian studies; on the interpretation of certain verses of Dante, etc. The nomenclature of his topographical chart of Mars, among other things, proves the accuracy and elegance of his classical learning.

He has been rewarded for a long and laborious life by the respect and admiration of his colleagues and by the continued interest of the larger public in his discoveries. Academies of science all over the world (with the singular exception of America) have elected him to membership and have awarded their medals and other honorary distinctions, and he has been decorated with orders of knighthood by Italy, Brazil and Russia. Finally, he is a life-senator of the Kingdom of Italy.

These tokens of particular appreciation and his widespread popular reputation are the rewards of a life devoted strictly to science. He has not gone out of his way to seek applause, though it has come to him in full measure. The graceful tribute of his colleagues signalizes his retirement from his official position, but we trust that he may be spared for many years to devote his genius to the science he has so greatly forwarded.

THE New York Central and Hudson River Railroad still announces in its time tables that the Empire State Express is the fastest regular train in the world; but this appears to be no longer correct. The Empire State Express traverses the distance from New York to Buffalo, about 440 miles, in eight hours and fifteen minutes, or at a rate of 53.33 miles per hour. The Sud Express on the Orleans and Midi Railway travels from Paris to Bayonne in eight hours and fifty-nine minutes. The distance is in this case 466¼ miles, the speed, including the time taken by six stops, is 54.13 miles per hour. The engine of the New York Central Railroad

has, however, a heavier load and is checked by necessary slacking as it passes through crowded streets and past level crossings. The fastest long-distance train in England is 'The Flying Scotsman,' which goes from London to Edinburgh, a distance of 393¼ miles, at a rate of 50.77 miles per hour. The United States holds the record for short distances in the run from Camden to Atlantic City, which is made by the Philadelphia and Reading Railroad at a rate of 66.6 miles per hour and by the Pennsylvania Railroad at a rate of 64.3 miles per hour. There is a considerable number of trains run at these rates or nearly as fast, and the rate is sometimes as great as eighty-eight miles an hour for distances of twenty miles. England seems to be now distinctly inferior to France and America in the speed for both long and comparatively short distances, although the road-beds are better, and although they do not have to contend with level crossings and runs through streets. The greater speed of the American trains appears to be due to the superiority of the engines. It is a fact that the speed of railway trains has increased little in recent years—scarcely at all in Great Britain for thirty years. If more rapid transit is required it will probably be found in the use of light trolley cars. There seems to be no technical difficulty in establishing a ten-minute service between Jersey City and Philadelphia, the time being reduced to one hour.

AMONG recent events of scientific interest we note the following: Prof. H. A. Rowland, of the Johns Hopkins University, has been awarded the grand prize of the Paris Exposition for his spectroscopic gratings, and Prof. A. Michelson, of the University of Chicago, the same honor for his echelon spectroscope. —The Balbi-Valier prize (3,000 francs) of the Venetian Institute of Sciences has been awarded to Professor Grassi, at Rome, for his work on the relation of Mosquitoes to malaria. —The Paris Academy of Moral and Political Sciences has awarded its Audifred prize of the value of 15,000 francs to Dr. Yersin for the discovery of his anti-plague serum. —A movement has begun in London for the erection of a memorial in honor of the late Sir William Flower, which will consist of a bust and a commemorative brass tablet to be placed in the Whale Room of the Natural History Museum—one of the departments in which he was most interested and to which he devoted special care and attention. —A monument in honor of Pelletier and Caventou, the chemists, to whom the discovery of quinine is due, was unveiled at Paris on August 7. An address was made by M. Moissan, president of the committee, who presented the monument to the city of Paris, and by other speakers. —Milne Edwards has by his will bequeathed his library to the Paris Jardin des Plantes, of which he was a director. It is to be sold and the proceeds to be applied toward the endowment of the chair of zoology which he held. He also leaves 20,000 francs to the Geographical Society, of which he was president, for the establishment of a prize and 10,000 francs to the Société des Amis des Sciences. —The collection of jewels arranged by Mr. George F. Kunz and exhibited by Messrs. Tiffany & Co. at the Paris Exposition has been presented to the American Museum of Natural History by Mr. J. Pierpont Morgan. —The New York Board of Estimate and Apportionment has authorized the expenditure of $200,000 for the Botanical Garden and $150,000 for an addition to the American Museum of Natural History. —The Peabody Academy of Science at Salem, Mass., is trying to raise $50,000 for an addition to the museum building. Already over $26,000 has been pledged for the purpose.